DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH
AND
IMPERIAL FORESTRY INSTITUTE

FOREST PRODUCTS RESEARCH

BULLETIN No. 3

BRITISH HARDWOODS

THEIR STRUCTURE AND IDENTIFICATION

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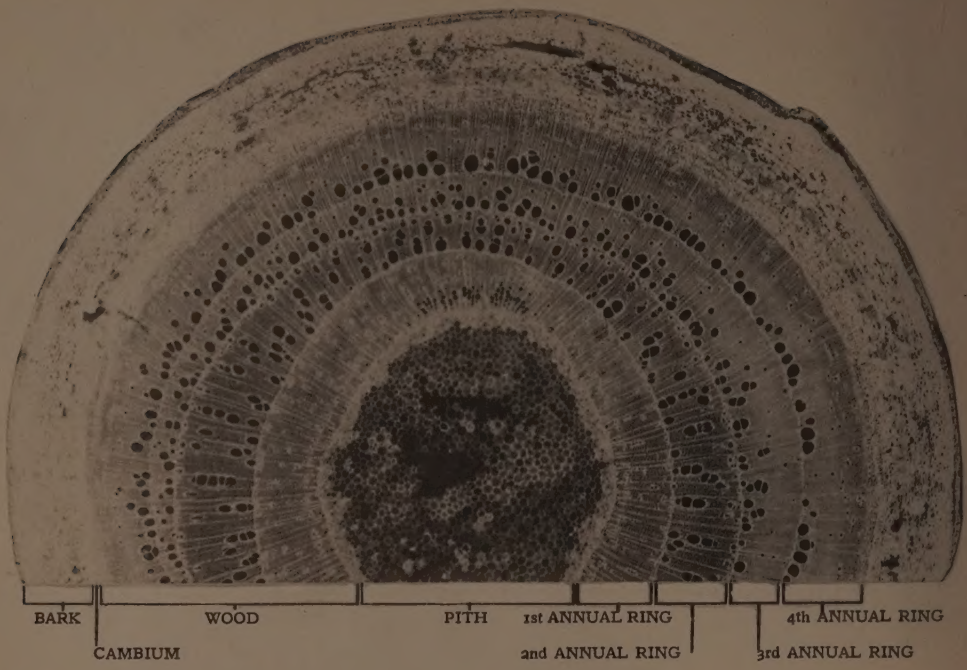

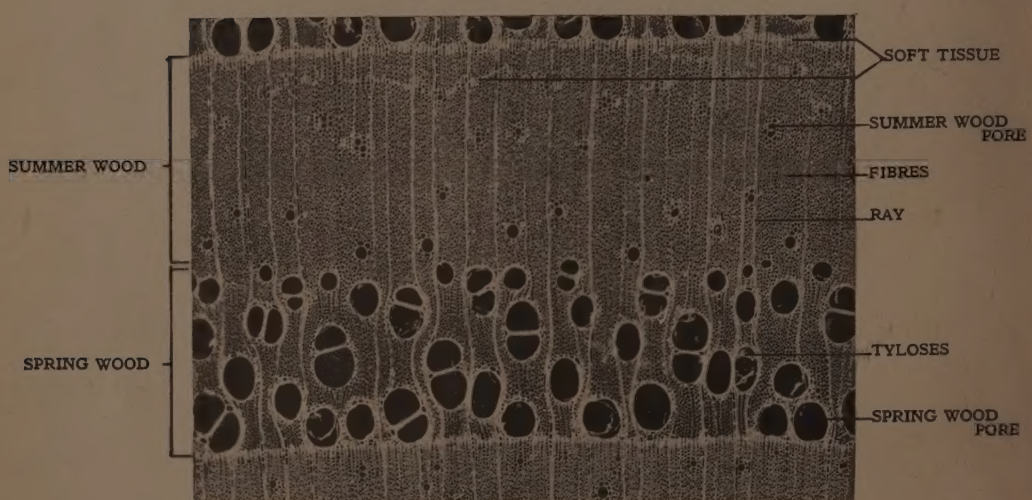

ABOVE. 4-YEAR OLD SHOOT OF ASH (×20)

BELOW. MATURE WOOD OF ASH (×30)

(Frontispie

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AND
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BRITISH HARDWOODS

THEIR STRUCTURE AND IDENTIFICATION

BY
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PREFATORY NOTE

ONE of the foremost requirements in dealing with timber, whether from the utilization or research aspect, is correct identification of the various species. The aim of the present publication is to provide descriptions of the structure of the more important British hardwoods, illustrated with suitable photomicrographs, which should be of assistance to timber users who wish to confirm the identity of the timbers they are handling. The key which is given at the end is intended for use in determining the name of an unknown sample of wood. The text is written in simple, non-technical language, and this, with an introduction on the structure of wood, should render the work useful to persons who have little or no previous knowledge of the subject.

Dr. J. Burtt Davy, of the Imperial Forestry Institute, has standardised the botanical names in accordance with the International Rules of Botanical Nomenclature, except in the case of a few well-established names, which it is hoped may be conserved, though not conforming strictly with the Rules. Where a choice between two well-known names is involved, the synonym has been inserted in brackets after the accepted name. The practice of giving capitals to certain specific names has been discarded, in accordance with the modern tendency towards simplification in nomenclature.

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BRITISH HARDWOODS

THEIR STRUCTURE AND IDENTIFICATION

INTRODUCTION

GENERAL

FROM long experience in the handling of timber many people are able to identify woods by their general appearance. This method is never very reliable and it is much more satisfactory to distinguish woods by definite descriptive features than to rely only on general impressions. A novice can learn the distinctive features of our common timbers in a few weeks and he will then be less likely to be deceived than anyone of far greater experience who " knows " his woods instinctively. The structure of wood can be accurately described and remains unaltered under conditions which may entirely change the external appearance of the timber. The aim of the present publication has been to describe the structure of all hardwoods grown in the British Isles which are of any economic importance, apart from fuel, so that they can be identified with no further apparatus than a sharp knife and a simple magnifying glass or hand lens. The descriptions are arranged for convenience in alphabetical order of common names. The botanical names of the timbers are printed in italics. The type descriptions of the British hardwoods are followed by shorter notes on related species and other woods which may resemble the native timber in name or general character. The photographs, which are ten times natural size, are intended to illustrate the structure of the wood as seen on an end surface, or cross section, under a lens. A key to the British woods has been added. This is intended to serve merely as a guide, and results obtained from the key should always be verified by reference to the type descriptions. The latter are intended to cover the range of variation likely to be found in normal samples of timber. They are not applicable to distorted wood such as is obtained from burrs.

The descriptions are based on the examination of a large number of specimens from different sources. Full use has been made of the existing literature on the subject, a select bibliography of which is given on page 47. In addition to the titles, short notes have been appended to give some indication of the scope of each book.

In both the descriptions and the key only those features have been included which can be seen on a clean-cut surface with the unaided eye or with a lens of a magnification of eight to ten times. Features only visible at higher magnifications have been omitted, as the use of a microscope is not generally practicable. It should be realised, however, that the examination of prepared sections under a microscope is always more reliable and is often the only certain means of distinguishing closely allied woods, such as willow and poplar. Technical terms have been avoided as far as possible ; those terms which have been used are explained in the brief account given of the structure of wood.

Any detailed account of the technical properties and uses of the woods described lies beyond the scope of this publication. Texture and weight, however, are sometimes useful aids to identification and have therefore been included. Weight is a very variable factor, different trees of the same species and even different parts of the same

tree showing considerable divergences. The weight of a block of wood also depends largely on its moisture content, so that records of specific gravities are useless for comparison unless the percentage of moisture present is also recorded. The weight of green or partially dried wood is apt to be very misleading as it may be more than double that of thoroughly seasoned wood. The weights given in the descriptions refer to wood in an " air dry " condition, that is, having a moisture content of between 12 and 15 per cent. Use has been made of published figures where these are based on a definite moisture content, and of unpublished data from the Forest Products Research Laboratory. In addition, specific gravity determinations have been made at 12 per cent. moisture content for all the woods described. The complete range of weight for any wood is too wide to be of much practical value in identification; the figures given indicate the limits within which most specimens will fall. The following terms have been used:—

Light	Less than 35 lb. per cu. ft.
Moderately heavy	35—50 lb. per cu. ft.
Heavy	50—60 lb. per cu. ft.
Very heavy	More than 60 lb. per cu. ft.

STRUCTURE OF WOOD

Wood is built up of innumerable tube-like units to which the name " cell " was originally given on the analogy of a honeycomb. But while in a honeycomb the cells are all approximately the same, the structure of wood is much more complex, its cells varying considerably in both size and shape according to the functions which they perform in the living tree. In the hardwoods certain types of cell are adapted to special requirements, such as conduction of water from the roots to the crown and mechanical rigidity to enable the crown to be raised above the ground and at the same time withstand the effect of wind. The water-conducting cells have enlarged central cavities through which water can flow, while the strengthening cells are thick-walled and produce dense tissue. A third type of cell, which is distinct from these two, has been developed in connexion with the storage of food materials produced by the leaves. The storage and movement of food supplies involve chemical changes, such as the conversion of insoluble starch into soluble sugars, which can only be carried out by living cells, whereas mechanical rigidity and the conduction of water involve no living process. Consequently, the storage cells are the only cells in the wood which remain alive to carry on their functions after the year in which they are formed.

In each species of tree these types of cell are arranged in the wood according to a definite plan. Variations in the arrangement and individual character of the cells produce marked differences in the properties of woods and afford a ready means of distinguishing them.

Softwoods and Hardwoods

Commercial timbers fall into two groups, softwoods and hardwoods. Generally speaking, " softwood " includes timber derived from coniferous trees, and " hardwood " timber from broad-leaved trees. This distinction is made irrespective of the literal meaning of the terms, there being many very soft hardwoods and some comparatively hard softwoods.

The two types differ quite definitely in structure and, with certain exceptions, in general properties. They can be easily distinguished by the presence of pores or

vessels in the hardwoods and their absence in the softwoods. Certain softwoods, e.g., spruce and pine, have characteristic resin ducts which appear on an end surface as minute spots or holes. These bear a slight resemblance to the pores of hardwoods but can hardly be mistaken for pores on account of their relatively small number. The appearance of pores and resin ducts is contrasted in figs. 1—6, which also illustrate the relatively simple structure of the softwoods compared with that of the hardwoods. In the softwoods about ninety per cent. of the wood consists of a single type of cell, known as a *tracheid*, which serves the double purpose of conducting water and giving strength to the timber. In the hardwoods these two functions are performed by different types of cell, which are described in detail in a later section.

Annual Rings

Formation of new wood.—The trunk of a tree increases in size by the addition of concentric layers on the outside of the woody cylinder. New wood is produced by a very thin sheath of specialized cells, known as the *cambium*, which lies between the bark and the wood. During the growing season cells of the cambium are constantly dividing and giving off new cells both on its inner and outer sides. Those on the inside develop into new wood and those on the outside into new bark.

Spring and summer wood.—Wood formed at the beginning of the growing season (spring wood) is generally less dense than that formed at the end (summer wood), see frontispiece. When growth ceases for the year, the outer rows of cells consist of dense summer wood, but on the resumption of growth in the following spring the tree immediately starts putting on light spring wood which contrasts with the previous dense zone of summer wood. It is this contrast which marks the *annual rings*, the sharpness with which they are defined varying considerably in different kinds of wood. In the softwoods, the greater density of the summer wood is mainly due to an increase in the thickness of the cell walls. In the hardwoods, the most important factors are the size and distribution of the pores. On these also depends the effect of ring-width on quality of timber. This is discussed later (see page 4).

Periods of growth.—In the British Isles new wood is formed during the period April to September. During the rest of the year the cambium is dormant and normally produces no new wood cells. This results in the production of a fresh ring of wood each year. In the tropics, however, the year is not always sharply divided into a single growing season followed by a resting period. Although zones of growth are often visible they do not necessarily correspond with annual periods. In such cases the term " growth ring " is therefore preferable to " annual ring."

STRUCTURAL FEATURES OF HARDWOODS

The principal elements of which hardwoods are composed are (1) Vessels or Pores, (2) Fibres, (3) Parenchyma or soft tissue, (4) Rays. These are described in detail below.

1.—Vessels or Pores

General characteristics.—Vessels are specially adapted elements whose function is the conduction of water. They consist of vertical series of open-ended cells arranged one above the other like a row of drain pipes and continuous for a long way up and down the tree. In the course of their development these cells become enlarged to a

considerably greater size than the surrounding cells and lose their living contents. When cut across on an end surface, i.e., at right angles to the grain of the wood, the vessels appear as small holes, commonly termed *pores*, which in coarse-textured woods, such as oak or ash, are clearly visible to the naked eye. In woods of finer texture, such as sycamore and beech, they can only be distinguished with the aid of a lens. On longitudinal surfaces they appear as grooves or scratches, which are long on a surface cut parallel to the grain but are shorter on oblique surfaces. The term *vessel lines* has been used to denote this aspect of the vessels on longitudinal surfaces. In many woods the vessel segments, or individual cells which compose the vessels, can be distinguished with the aid of a lens on longitudinal surfaces.

Ring-porous and diffuse-porous woods.—Woods in which the pores of the spring wood are distinctly larger than those of the summer wood and form a well-defined zone or ring are called *ring-porous* (frontispiece and fig. 1), while woods in which the pores are scattered or diffused throughout the annual ring, without any marked difference between those of the spring wood and summer wood, are known as *diffuse-porous* (figs. 3 and 4). The presence of a pore ring is an extremely useful feature in identification as it is easily observed and is characteristic of several of our commonest timbers. The following British woods are ring-porous: ash, chestnut, elm, false acacia, laburnum, mulberry and oak. In walnut (fig. 2) the spring wood pores occasionally form a loose ring, but in most cases the arrangement is typically diffuse-porous. Cherry also shows a tendency to form a pore ring but to a less degree. All the other British timbers described are diffuse-porous.

In ring-porous woods the width of the ring bears an important relation to quality. Rapid growth produces wide rings with a large proportion of dense summer wood and high strength values. The result of slow growth, on the other hand, is to produce narrow rings in which the proportion of dense summer wood is reduced, and the timber is consequently light and weak (see wide-ringed ash, fig. 8, and narrow-ringed ash, fig. 9). Where strength is of importance, as is commonly the case in the uses to which ash and hickory are put, fairly wide-ringed timber is always preferred. In diffuse-porous woods, where there is no such sharp difference between the inner and outer portions of the ring, the width of the ring is of comparatively little importance.

Vessel pattern.—The arrangement of the vessels or pores, particularly in the summer wood, is often useful in identification. In oak and chestnut, for example, the summer wood pores are arranged in irregular groups or lines parallel to the rays (figs. 29 and 1), while in elm and laburnum they tend to form festoons running across the rays (figs. 20 and 26). It is possible, by examining the pores alone, to distinguish the following woods, white oak, red oak, evergreen oak, silky oak, she oak, and Tasmanian oak (figs. 29—35). In slow grown ring-porous woods, where the rings are very narrow, the summer wood may be so reduced that the typical arrangement of the pores becomes obscure (see narrow-ringed ash, fig. 9). It is important, therefore, when examining a sample for identification, to choose a fairly wide, well-developed growth ring.

Size.—The size of the pores also provides a valuable diagnostic feature. For purposes of comparison it is convenient to describe the size of the pores in terms of their visibility. The following terms have been used in this connexion :—

Large, conspicuous to the naked eye, e.g., chestnut (fig. 1) and oak.
Moderate sized, clearly visible to the naked eye, e.g., walnut (fig. 2) and elm.
Small, barely visible to the naked eye, e.g., plane (fig. 3) and beech.

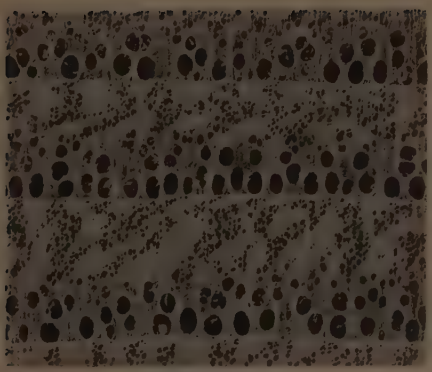


Fig. 1 CHESTNUT,
Cqstanea sativa MILL.

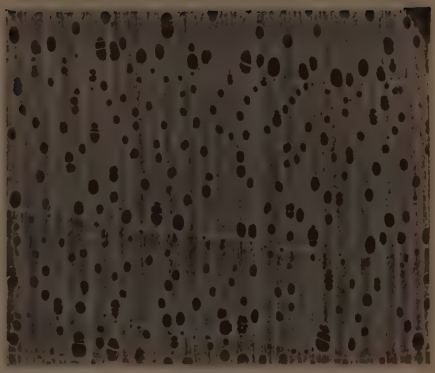


Fig. 2 WALNUT,
Juglans regia L.

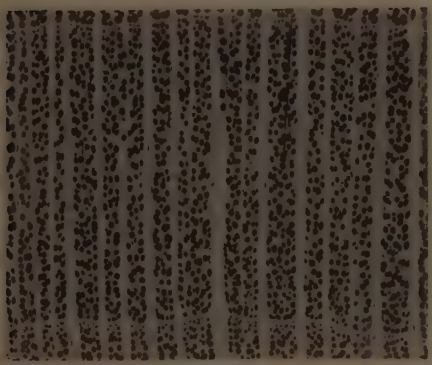


Fig. 3 PLANE,
Platanus acerifolia WILLD.

Fig. 4 HAZEL,
Corylus avellana L.

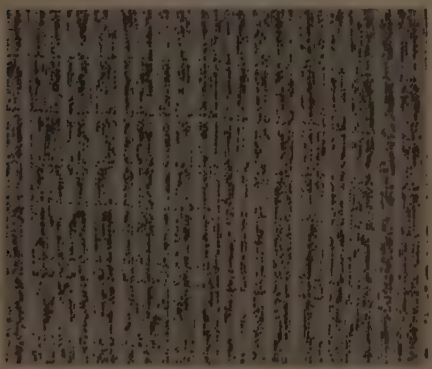


Fig. 5 HOLLY,
Ilex aquifolium L.

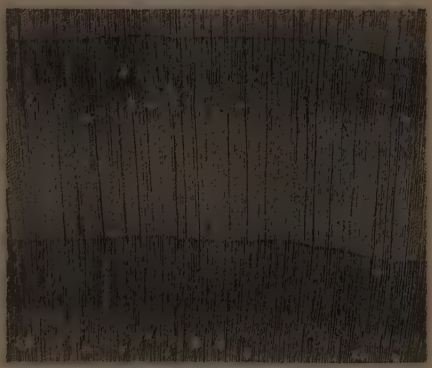


Fig. 6 CORSICAN PINE,
Pinus laricio POIR.

Very small, invisible to the naked eye, but distinct with a lens, e.g., hazel (fig. 4) and horse chestnut.

Extremely small, barely visible even with a lens, e.g., holly (fig. 5) and box.

Tyloses and internal deposits.—Vessels that have ceased to function as water conductors often become plugged with bladder-like growths known as *tyloses* (see frontispiece). In certain woods, e.g., false acacia (fig. 21), the presence of tyloses in the heartwood and inner sapwood is very characteristic (see also chestnut, fig. 1).

The vessels of the heartwood may also contain deposits of gum, lime, etc., a feature which is common in many tropical woods. Woods with a tendency to produce gum or resin sometimes develop specialized ducts, somewhat similar to those in pine and larch, but these are rare in hardwoods from temperate climates and occur apparently only as the result of wounding, e.g., cherry. In tropical woods they are more common and are often a normal feature of the wood.

2.—Fibres

The cells chiefly concerned with the mechanical strength of the tree are the *fibres*, long, narrow, thick-walled elements which constitute the bulk of the wood substance or ground tissue (frontispiece). The fibres and their arrangement play an important part in determining the technical properties of timber, but they are of little direct value in identifying woods with a lens as they are generally too fine to be distinguished. Certain general characters, however, such as texture and density, depend largely on the microscopic structure of these cells.

3.—Parenchyma or Soft Tissue

The function of storing food materials is performed by the so-called *parenchyma* or *soft tissue*, consisting of thin-walled, brick-shaped cells, often visible on an end surface as fine lines or patches which are light coloured in contrast with the darker background of the fibres (frontispiece). Their visibility is generally increased by moistening the surface of the wood. Soft tissue may occur in several positions, for instance, surrounding the vessels and sometimes joining them to form chains or bands, e.g., false acacia (fig. 21), or as fine lines running tangentially to the annual rings and at right angles to the rays, e.g., walnut (fig. 2), or as a fine line bounding the annual ring, e.g., sycamore (fig. 39).

Some hardwoods have a special type of water-conducting cell, known as the *tracheid*, which is much smaller than the vessel and which is often found in proximity to it. This gives rise to tissue which is indistinguishable from parenchyma or storage tissue without a microscope. For example, in oak the lighter coloured tissue in which the vessels are embedded is actually composed of tracheids and not parenchyma. But since no such distinction can be made with a lens both have been included in the term "soft-tissue."

Pith flecks.—These are small areas of parenchymatous tissue which are visible as brown spots on an end surface and as dark streaks on longitudinal surfaces. They are generally the result of injury by insects. Pith flecks are common in species of willow, poplar, birch, alder, and in woods of the family Rosaceae (cherry, pear, apple, etc.). Although they are not invariably present, they sometimes serve to indicate the species when taken in conjunction with other characters. Pith flecks are generally more common near the centre of the tree.

4.—Rays

General characteristics.—Storage tissue is also present in another and more easily recognised form in what are known as the medullary rays, or simply *rays*. These consist of narrow strands of horizontal cells which appear on an end surface as lines of varying width radiating from the centre of the tree (frontispiece). They are generally lighter in colour than the ground tissue. On a quarter-cut or radial surface they are sometimes conspicuous, as in the case of oak, and appear as horizontal flakes, which produce the silver grain on quarter-sawn timber. On a plain-sawn or tangential surface they appear as boat or spindle-shaped lines slightly darker in colour than the ground tissue, and are generally rendered more distinct by moistening the surface.

Size.—The size of the rays, as seen on an end surface, varies considerably in different woods, and being relatively constant for any one species affords a valuable aid to identification. Oak and chestnut, for example, may be easily distinguished by their rays. In chestnut the rays are all very fine and visible only with a lens. In oak the majority of the rays are also very fine and similar to those in chestnut, but scattered among these are very broad rays which are conspicuous to the unaided eye. When the rays in any wood are of two distinct sizes, broad and fine (fig. 4), the broad rays are known as *compound* or *aggregate*. The difference between these two types lies in their minute structure, a compound ray being one solid ray, whereas an aggregate ray really consists of numerous small rays grouped so closely together that to the unaided eye they look like one large ray. Compound or aggregate rays are characteristic of certain woods, notably oak, beech, hornbeam, alder and hazel. They are not always developed in young wood and may be entirely lacking in the first few annual rings of the trunk. The broad rays of plane might be mistaken for compound rays, but a careful examination reveals the presence of rays of all gradations in size from very fine to broad. In describing the size of the rays the following terms have been used:—

Extremely broad, e.g., evergreen oak (fig. 32).
Very broad, e.g., oak, alder, hazel (fig. 4).
Broad, e.g., plane, beech (fig. 3).
Moderately broad, e.g., holly, sycamore (fig. 5).
Fine, e.g., ash, walnut (fig. 2).
Very fine, e.g., chestnut, poplar (fig. 1).

Visibility is affected by colour and lustre and is therefore not entirely dependent on size.

Ripple marks.—The term "ripple marks" is given to the very fine horizontal lines or striations, which are visible on the tangential or plain-sawn surface of certain woods. This feature is more common in tropical woods, for instance, mahogany and satinwood, than in woods from temperate climates. Ripple marks sometimes occur in horse chestnut; they are due to the rays being arranged in horizontal tiers or storeys, as seen on a tangential surface, instead of being scattered irregularly as is usually the case in other woods. In the lime, a storied arrangement, not of the rays but of the vertical cells, produces a similar appearance.

HEARTWOOD AND SAPWOOD

The trunk of a tree commonly shows a coloured central core of *heartwood* which is more or less distinct from the lighter outer portion or *sapwood*. Where there is no clear colour distinction and the wood is uniform in colour the tree is often called a sapwood tree.

The terms heartwood and sapwood are used by botanists in a wider sense, based on the functions of the wood in the living tree. All the wood of a young tree plays an active part in the life of the tree. But as the tree increases in size such activities as the conduction of water are taken over by the newer rings added on the outside. As the older wood is superseded, it gradually ceases to take any part in the life of the tree and in most cases even the storage tissue dies.* It is to this dead wood that the term heartwood is applied in its wider sense, irrespective of whether there is any colour difference or not. Such wood may be completely rotted away without interrupting the life processes of the tree, as is commonly the case in old pollard willows.

The dying cells of the inner sapwood sometimes produce various substances, such as tannin, which diffuse through the surrounding tissues. These often impart a distinctive colour to the dead central core or heart and render it more durable. The actual structure of the heartwood remains unchanged apart from the possible formation of tyloses in the vessels. Mechanical tests have proved that the change from sapwood to heartwood has no effect on the strength of the timber except in the case of certain very resinous woods.

Some tests on hickory carried out in America are of interest in this connexion. The manufacturers maintained that the white sapwood of hickory was stronger than the red heartwood. Mechanical tests showed, however, that other things being equal, there was no difference in strength between the sapwood and heartwood of the same tree. But the manufacturers were right in practice; for young hickory trees of rapid growth consist mainly of sapwood, while older, slow-grown trees of the same size consist mainly of heartwood; consequently most of the white sapwood hickory on the market is wide-ringed and the red heartwood narrow-ringed, a difference which materially affects the strength of a ring-porous wood, such as hickory.

* Recent investigations in America have shown that individual cells may remain alive in the heartwood of some trees for more than a hundred years. It is improbable that these cells play any important part in the living functions of the stem.

DESCRIPTIONS OF THE WOODS

ALDER, *Alnus glutinosa* GAERTN.

Fig. 7

ALDER

COMMON ALDER, BLACK ALDER—*Alnus glutinosa* Gaertn.
WHITE OR GREY ALDER—*Alnus incana* Moench.

General Properties.—Light to moderately heavy, 30-40 lb. per cu. ft.; generally straight-grained; texture fine and uniform; cuts easily but with a dull, lustreless surface which obscures the finer details of the structure.

Colour white when first cut, darkening to pale reddish brown, flecked with lines and spots due to occasional broad rays and pith flecks; sapwood and heartwood not distinct. The end surfaces of freshly felled logs turn a characteristic orange-brown colour on exposure to the air.

Annual rings distinct to indistinct on end surface; boundary marked by a narrow band of denser summer wood. The boundaries of the rings give to a plain-sawn surface a "watered" effect.

Pores small, barely visible to the naked eye, distinct with a lens; marked tendency to radial arrangement; abundant in spring wood, becoming smaller and less numerous towards the outside of the ring.

Vessel lines faintly visible as fine scratches.

Soft tissue in a fine line terminating the annual ring, faintly visible with a lens.

Rays mostly very fine and numerous, visible only with a lens. Occasional broad (aggregate) rays present, scattered promiscuously, often absent over wide areas, particularly near the centre of the tree; dull and inconspicuous on end surface, generally apparent on plain-sawn or tangential surface as dark vertical lines one to several inches in height.

Pith flecks common, visible as rust coloured spots or streaks on longitudinal surface as seen on plywood.

IMPORTED ALDER

Alder imported from the Continent is from the same species as those found in Great Britain.

ASH

English Ash—*Fraxinus excelsior* L.

General Properties.—Moderately heavy, 35-55 lb. per cu. ft., average about 45 lb.; remarkably tough and elastic; characteristically straight-grained; texture fairly coarse. Plain-sawn and rotary-cut veneer shows a pronounced figure due to the contrasting zones of porous spring wood and dense summer wood.

Colour white to light brown, often tinged with pink; sapwood and heartwood are not as a rule sharply defined, but old trees sometimes contain a dark brown or black heart.

Annual rings distinct; boundary marked by a ring of large spring wood pores (ring-porous).

Pores of the spring wood large and conspicuous, oval, in a wide, loose ring; tyloses present but not abundant. Transition to summer wood zone fairly abrupt. Pores of the summer wood scattered, single or in groups of 2-3, much smaller than the spring pores, just visible to the naked eye as light dots, distinct under a lens.

Vessel lines distinct as coarse grooves.

Soft tissue (*a*) surrounding the pores and producing the appearance of a blurred margin or halo; often extending as lateral wings from the pores of the outer summer wood and sometimes forming short irregular lines or chains; (*b*) in a fine, light coloured line terminating the annual ring.

Rays fine, faintly visible to the naked eye, about as wide as the small summer wood pores.

Imported Ash

Ash imported from the continent is furnished by the same species as that found in Great Britain.

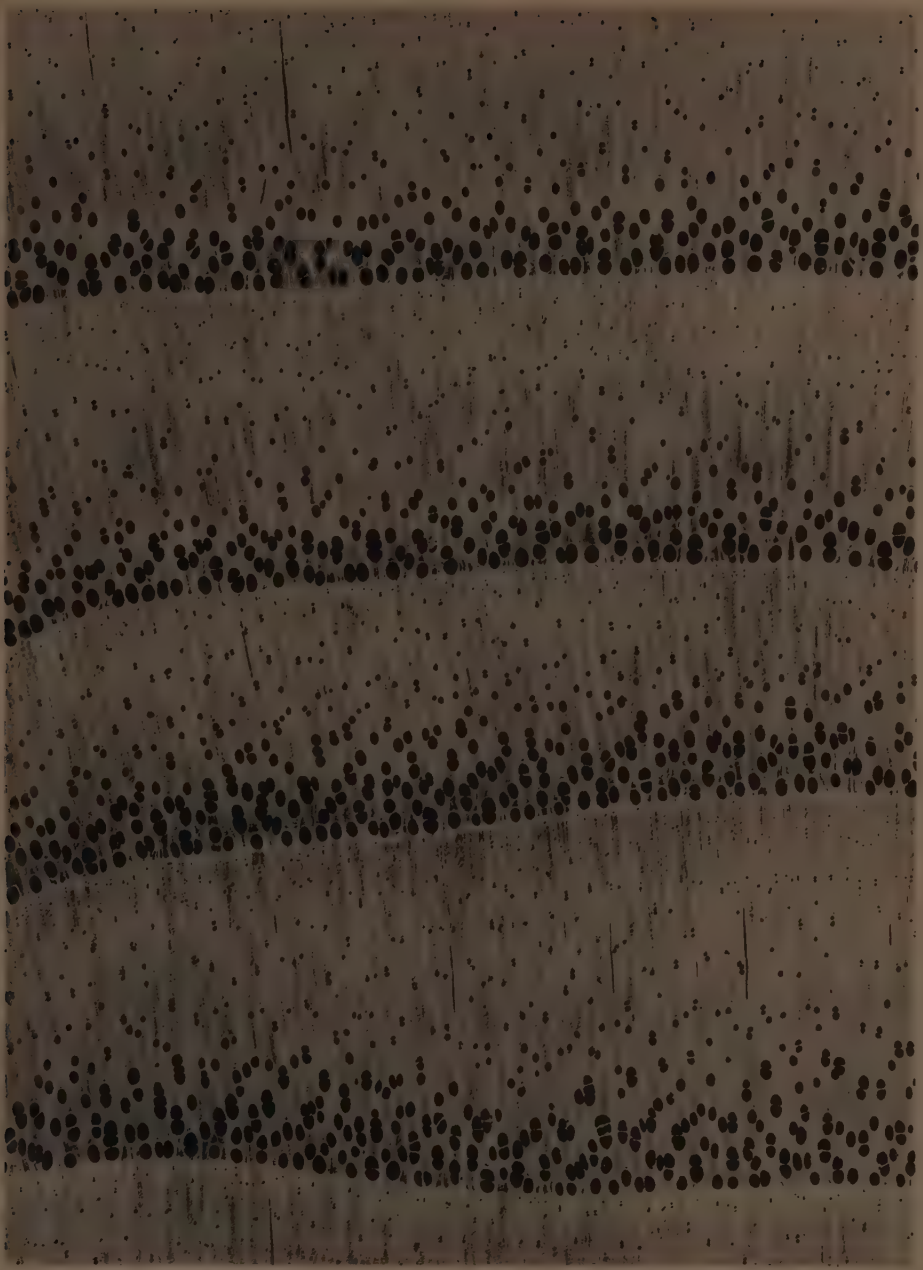
Canadian and American White Ash is the product of *Fraxinus americana* L. Several other species of American ash are also imported.

Japanese Ash is derived from *Fraxinus mandshurica* Rupr.

The structure of these timbers is essentially similar to that of English ash.

Other Timbers Known as Ash

The name "ash" is applied in Australia to a group of *Eucalyptus* woods which bear a superficial resemblance to true ash. *Eucalyptus delegatensis* R.T.B., *E. obliqua* L' Hérit. and *E. regnans* F.v.M. are known



ASH, *Fraxinus excelsior* L.

Fig. 8

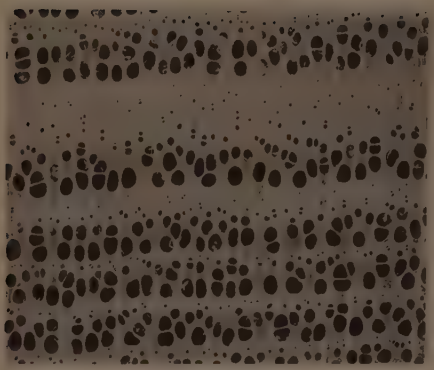


Fig. 9 ASH,
Fraxinus excelsior L.

Fig. 10 HICKORY,
Carya (*Hicoria*) *sp.*

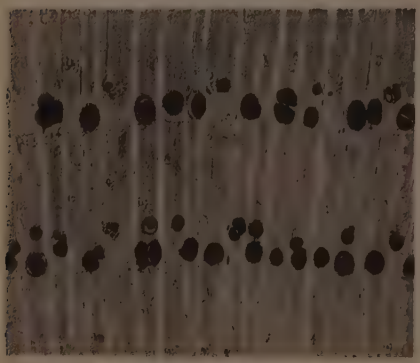


Fig. 11 TREE OF HEAVEN,
Ailanthus glandulosa DESF.

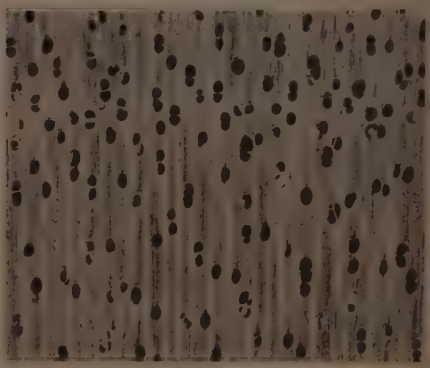


Fig. 12 QUEENSLAND MAPLE,
Flindersia chatawaiana BAILEY.

Fig. 13 TASMANIAN BEECH,
Nothofagus cunninghamii OERST.

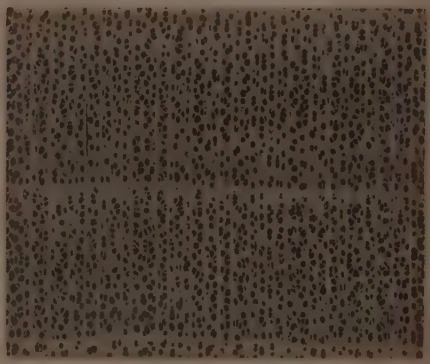


Fig. 14 YELLOW POPLAR,
Liriodendron tulipifera L.

as MOUNTAIN ASH, TASMANIAN ASH and TASMANIAN or VICTORIAN OAK. The timber is straight-grained and fissile, not unlike ash when first cut, but more nearly resembling plain oak when seasoned (see under Oak, page 33).

The true MOUNTAIN ASH or ROWAN, *Pyrus aucuparia* Gaertn., owes its name to the resemblance of its leaves to those of the ash. The timber is described under pear (see page 35).

TIMBERS SOMETIMES CONFUSED WITH ASH

HICKORY, from species of *Carya* (*Hicoria*) is easily distinguished by the numerous fine tangential lines of lighter coloured soft tissue in the summer wood (fig. 10). The sapwood is white (white hickory), the heartwood brown to reddish brown (red hickory). A prejudice exists against red hickory, which is excluded from the higher grades. It has been proved conclusively, however, that, other things being equal, sound hickory has the same strength, toughness and resistance to shock regardless of whether it is red, white or mixed red and white.

The wood of the TREE OF HEAVEN, *Ailanthus glandulosa* Desf., a native of eastern Asia which is occasionally planted in England as an ornamental tree, bears a certain resemblance to ash and may be mistaken for it. It is yellowish in colour and coarser in the grain than ash. It may be most readily distinguished by the size of the rays, which are clearly visible to the naked eye (fig. 11) and by the presence of gum in the pores. Reports of its mechanical properties as compared with ash are conflicting.

BEECH

Common Beech—*Fagus sylvatica* L.

General Properties.—Moderately heavy, 40–55 lb. per cu. ft., average about 45 lb.; straight-grained, splits easily along the rays; texture fine and uniform.

Colour whitish or pale brown, darkening to light reddish brown on exposure; steaming deepens the colour to a warm reddish tint; sapwood and heartwood not sharply defined.

Annual rings moderately distinct, curving outwards slightly between the broad rays; boundary marked by a narrow zone of denser summer wood.

Pores small, barely visible to the naked eye, distinct with a lens; crowded, except in the narrow zone of dense wood limiting the annual ring, giving the wood a spongy appearance under a lens.

Vessel lines distinct only with a lens.

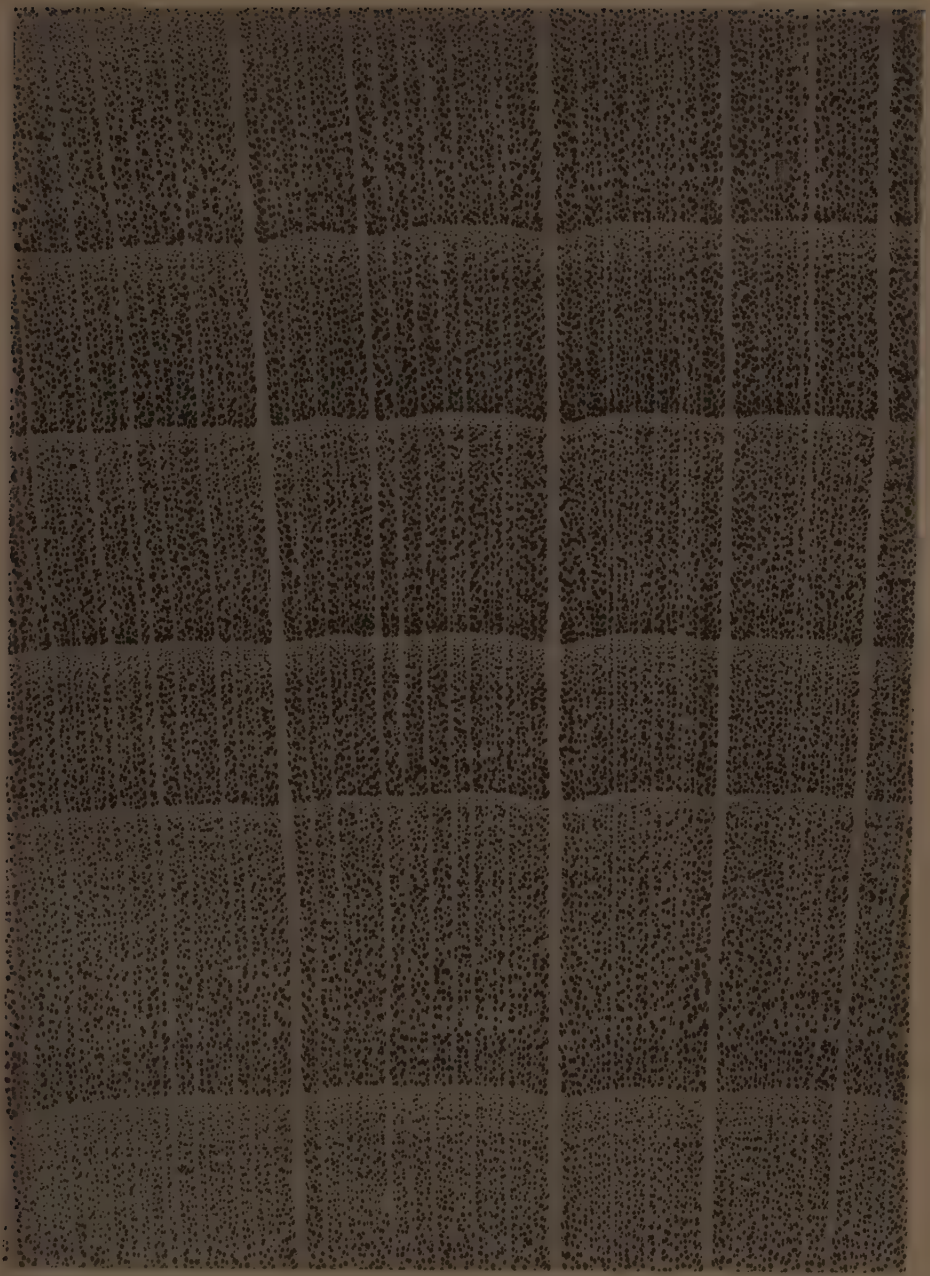
Rays of two distinct sizes. The larger (compound rays) bright and conspicuous on end surface; rather widely spaced (not so numerous as in plane); visible on longitudinal surfaces as dark lines or flakes up to one-sixth of an inch in height. The smaller rays fine and indistinct without a lens.

Other Species of Beech

Beech imported from the continent is from the same species as that found in Great Britain

North American Beech, *Fagus grandifolia* Ehrh., is very similar to the European species.

The beeches of the southern hemisphere are now generally referred to a separate genus, *Nothofagus*. The wood resembles English beech in grain and general properties, is pinkish in colour, but lacks the characteristic broad rays (fig. 13). Tasmanian Beech or Myrtle is *Nothofagus cunninghamii* Oerst. The principal New Zealand species are Red Beech, *Nothofagus fusca* Oerst., and Silver Beech or Southland Beech, *Nothofagus menziesii* Oerst.



BEECH, *Fagus sylvatica* L.

Fig. 15

BIRCH, *Betula pubescens* EHRH.

Fig. 16

BIRCH

WHITE BIRCH—*Betula pubescens* Ehrh.*
SILVER BIRCH—*Betula alba* L. (*B. verrucosa* Ehrh.)*

General Properties.—Moderately heavy, 33–50 lb. per cu. ft., average about 45 lb.; fairly straight-grained; texture fine and uniform; cuts with a smooth bright surface.

Colour white to light brown; sapwood and heartwood not distinct.

Annual rings rather indistinct on end surface; boundary marked by a light coloured line of soft tissue and sometimes by a darker band of summer wood; visible as darker lines on a tangential surface as seen on plywood.

Pores small, barely visible to the naked eye but distinct with a lens; single or in radial groups of 2–4; uniformly distributed, diminishing slightly in size towards the outer part of the ring.

Vessel lines visible as fine scratches.

Soft tissue in a fine line terminating the annual ring, usually distinct under a lens.

Rays fine to very fine, barely visible to the naked eye, distinct under a lens on a moistened end surface.

Pith flecks fairly common, visible as rust-coloured spots and streaks.

IMPORTED BIRCH

Birch imported from the Continent in the form of plywood is from the same species as those found in Great Britain.

The timber imported from Canada is mainly YELLOW BIRCH, *Betula lutea* Michx. Supplies from the United States consist of mixed YELLOW BIRCH and SWEET or CHERRY BIRCH, *Betula lenta* L. The wood of the two species is very similar and they are not usually separated. It is heavier and darker in colour than European birch, with a more or less pronounced reddish tinge. The wood sometimes shows a wavy or curly grain.

Canadian WHITE or PAPER BIRCH, *Betula papyrifera* Marsh., has also been imported in small quantities. This is a lighter wood than the other North American species and more nearly resembles European birch.

JAPANESE BIRCH, from various species of *Betula*, is comparable to the American rather than the European timber.

* These two species were formerly united under the name *Betula alba* L.

BOX

Buxus sempervirens L.

General Properties.—Heavy to very heavy, 53-70 lb. per cu. ft., generally between 55 and 60 lb.; grain variable; texture very fine and uniform.

Colour light yellow, with darker bands marking the annual rings; sapwood and heartwood not distinct.

Annual rings fairly distinct on a clean-cut end surface; very narrow; fairly regular; boundary marked by a narrow band of denser summer wood.

Pores extremely small, faintly visible with a lens as white dots; mostly single, uniformly distributed, less numerous in the narrow denser zones of summer wood.

Vessel lines barely visible even with a lens.

Soft tissue not visible with a lens.

Rays very fine and numerous, barely visible to the naked eye, distinct with a lens.

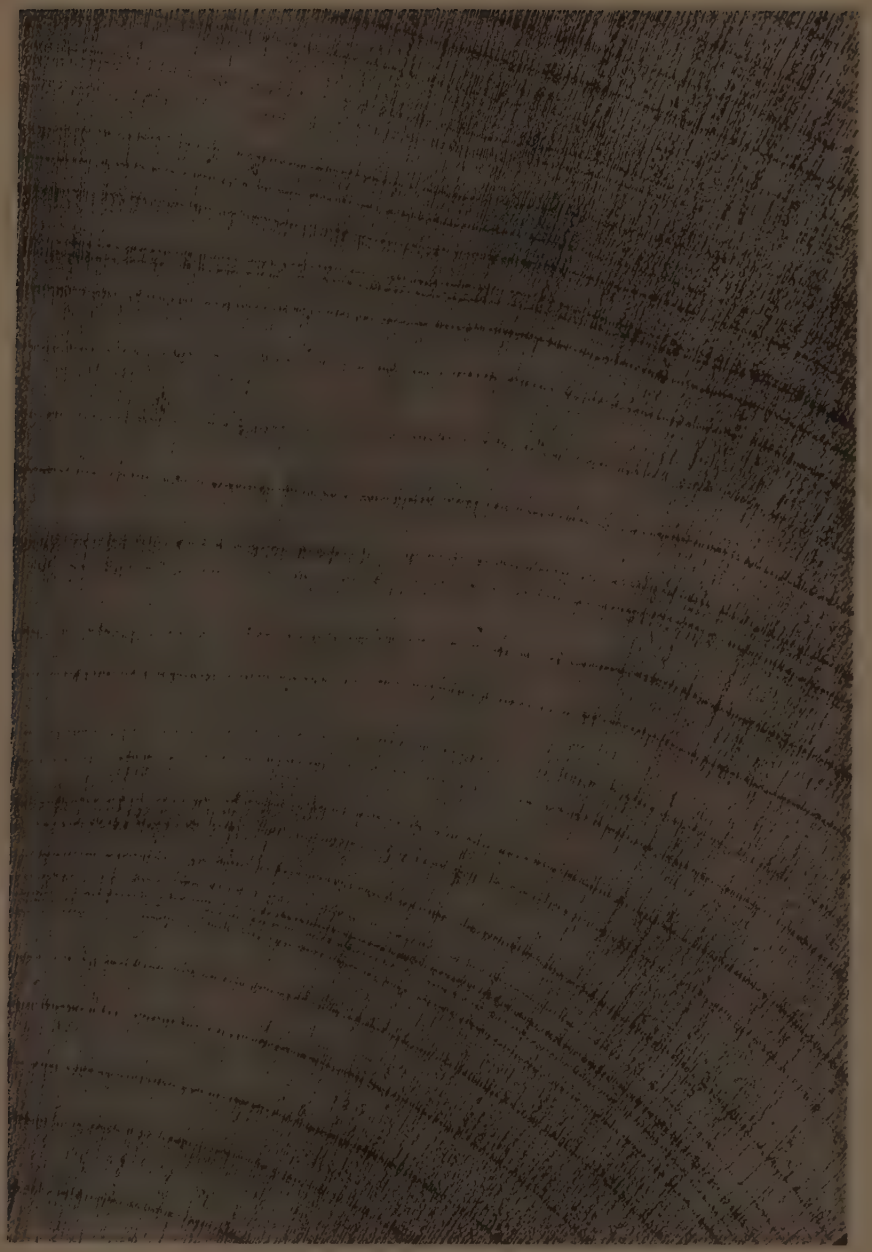
Pith flecks absent.

Commercial Boxwoods

Buxus sempervirens furnishes the true boxwood or Turkish Boxwood of commerce. The tree is of limited occurrence in Great Britain, but is common throughout southern Europe and extends across Asia; it attains its best development in the Caucasus. Several closely related species occur in different parts of the world, but with the exception of the South African Cape Boxwood, *Buxus macowani* Oliv. (*Buxella macowani* Van Tiegh.), to which the above description of *Buxus sempervirens* applies, none of these are of more than local importance.* There are, however, various other woods which, though unrelated to the true boxwood, possess its peculiar qualities in such a marked degree as to be commonly accepted as boxwoods by the trade.† The fine structure of these woods makes it a difficult matter to guarantee the identity of the different species without recourse to microscopic examination. The main features of the principal boxwoods as seen with the naked eye and a hand lens are given below.

* *Buxus balearica* Lam. may possibly furnish some of the Turkish boxwood of commerce. The wood is practically identical with that of *Buxus sempervirens*.

† A detailed account of the boxwoods of commerce is given in "Boxwoods," by Samuel J. Record and George A. Garratt, Yale University School of Forestry, Bulletin No. 14, 1925.



BOX, *Buxus sempervirens* L.

Fig. 17

CHERRY

GEAN, MAZZARD OR WILD CHERRY—*Prunus avium* L. and other species.

General Properties.—Moderately heavy, 35-50 lb. per cu. ft.; generally straight-grained; texture moderately fine and uniform.

Sapwood yellowish or pink when fresh; heartwood light brown or reddish, darkening on exposure.

Annual rings fairly distinct; boundary marked by a zone of spring wood with abundant pores.

Pores crowded in a well marked zone at the beginning of the annual ring, small, sometimes just visible to the naked eye; decreasing in size and number towards the outer part of the ring where they are single and in radial groups. Gum deposits common, scattered or forming dark lines or patches in the wood. Gum ducts sometimes present.

Vessel lines sometimes distinct owing to gummy contents.

Soft tissue not visible with a lens.

Rays distinct to the naked eye, wider than the pores; moderately conspicuous on radial surface.

Pith flecks sometimes present.

The wood of plum, *Prunus domestica* L., is similar to cherry. It is generally of a deeper colour, sometimes streaked with darker bands.

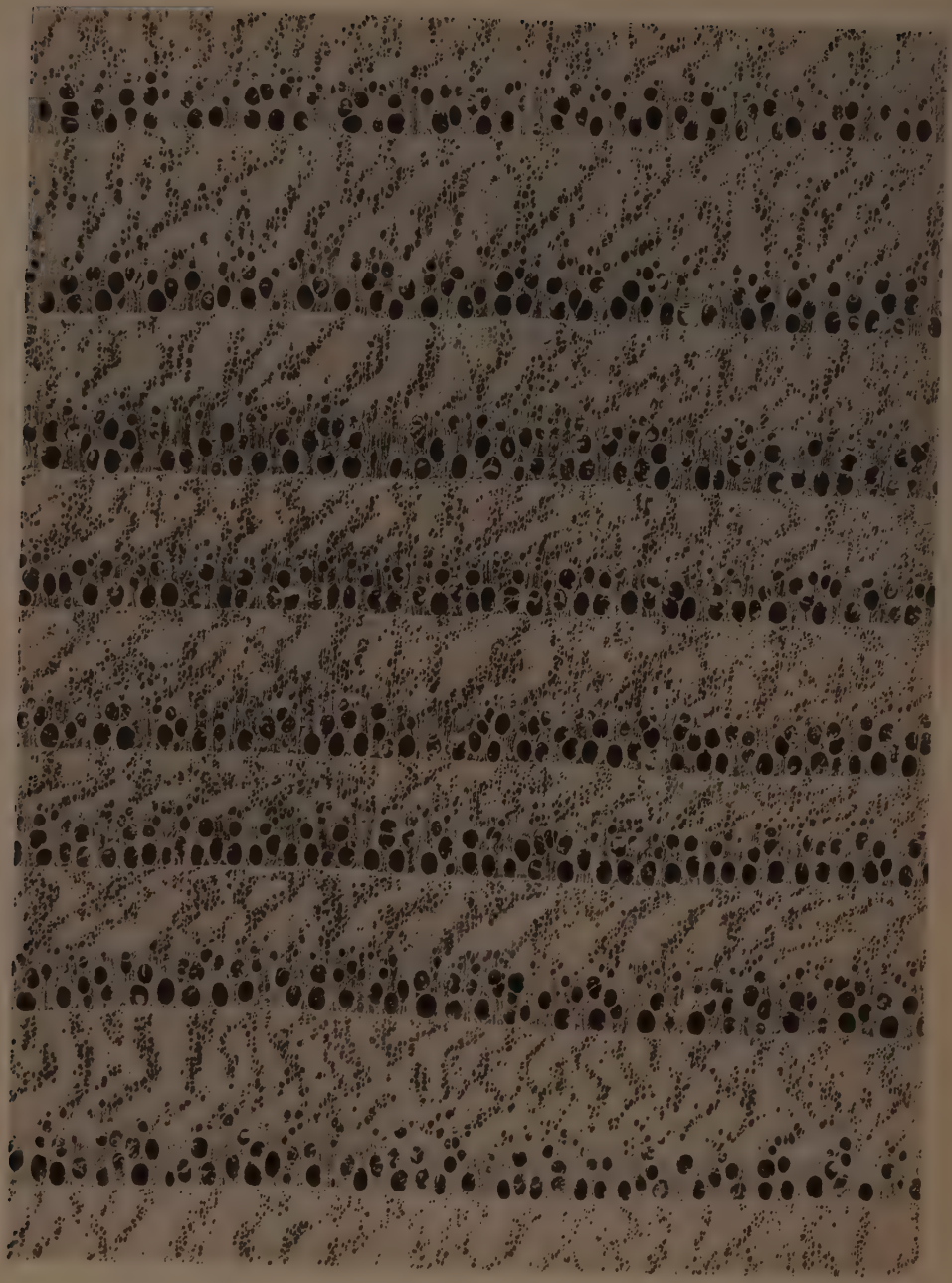
The heartwood of BLACKTHORN, *Prunus spinosa* L., is commonly streaked with purple when fresh. The annual rings are less distinct and the pores smaller than in cherry.

AMERICAN BLACK CHERRY is *Prunus serotina* Ehrh.

The AUSTRIAN CHERRY is *Prunus mahaleb* L.

CHERRY, *Prunus avium* L.

Fig. 18



CHESTNUT, *Castanea sativa* MILL.

Fig. 19

CHESTNUT

SWEET CHESTNUT, SPANISH CHESTNUT—*Castanea sativa* Mill. (*C. vesca* Gaertn.)

General Properties.—Light or moderately heavy, 30-45 lb. per cu. ft., average about 37 lb.; closely resembles oak in colour and texture; it is easily distinguished by the absence of broad rays and consequently lacks the characteristic silver-grain of figured oak. Generally not so hard as oak. The end surface sometimes has a rather spongy appearance. Coppice chestnut is generally wider-ringed and heavier; it is fairly straight-grained and splits easily; timber from old trees is often spiral-grained.

Sapwood narrow, light coloured; heartwood light to dark brown.

Annual rings distinct; boundary marked by a ring of large spring wood pores (ring-porous).

Pores of the spring wood large and conspicuous, oval, in a ring 2—3 rows wide, usually with a gradual transition to the summer wood pores. Tyloses moderately abundant in the heartwood. Pores of the summer wood in obliquely radial lines or branching groups, becoming very small towards the outer part of the ring.

Vessel lines distinct as coarse grooves.

Soft tissue surrounding the spring wood pores, lighter than the ground tissue of the summer wood.

Rays very fine, visible only with a lens.

IMPORTED CHESTNUT

AMERICAN CHESTNUT, *Castanea dentata* Borkh., is coarser in appearance than the British species.

ELM

Common English (Red) Elm—*Ulmus campestris* L.

General Properties.—Moderately heavy, generally between 33 and 43 lb. per cu. ft.; commonly cross-grained and difficult to split; texture coarse. Plain-sawn elm timber often has an irregular figure due to the uneven growth of the annual rings. The characteristic zig-zag markings between the rings are produced by the wavy tangential bands of small summer wood pores.

Sapwood light coloured; heartwood dull reddish brown.

Annual rings distinct; often uneven and irregular in width; boundary marked by a ring of large spring wood pores (ring-porous).

Pores of the spring wood large, in a well marked ring, usually 1-2 rows wide; sometimes plugged with white deposits of lime; tyloses present but not conspicuous. Transition to summer wood zone abrupt, less so in very wide rings. Pores of the summer wood very small and numerous, distinct only with a lens, in wavy tangential bands or festoons, more or less broken in the earlier wood, but continuous in the outer part of the ring.

Vessel lines.—The spring wood vessels appear as distinct brown grooves on longitudinal surfaces. The summer wood vessels are not individually distinct without magnification, but together produce a prominent zig-zag pattern on tangential or plain-sawn surface.

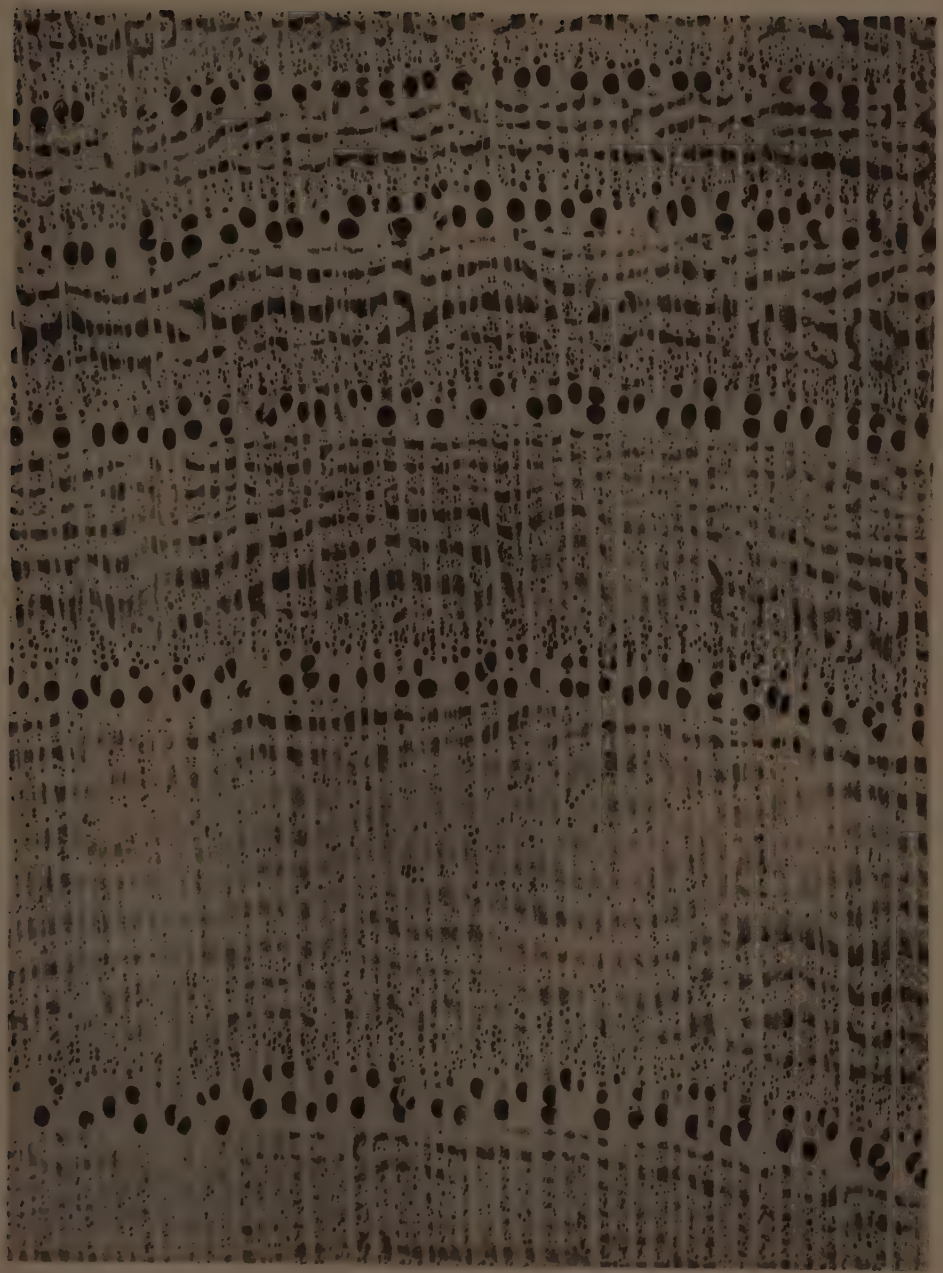
Soft tissue associated with the pores; not distinct with a lens.

Rays fine but visible to the naked eye on end surface; distinct on longitudinal surfaces, especially when moistened, as small dark lines or flakes.

Other Species of English Elm

After the common or red elm, so called from its dark red heartwood, the best known are the Dutch Elm, *Ulmus major* Sm., and the Wych Elm, *Ulmus montana* Stokes (*U. glabra* Hudson). There are several other species and hybrids of elm, the timbers of which are not as a rule specifically distinguished, and it is more than probable that several varieties are commonly grouped under the same commercial name.

The wood of Dutch elm is paler in colour than that of common elm and usually has a slightly wider pore-ring (commonly 2 rows wide). In wide rings the transition from spring to summer wood pores is less abrupt, but this structural feature is not sufficient to separate the two species with absolute certainty.



ELM, *Ulmus campestris* L.

Fig. 20

Wych elm also produces a light coloured wood (white elm timber) which is straighter grained than the other varieties. The pores of the spring wood are not so large as in the common elm and the transition from spring to summer wood pores is more gradual. The pore zone is in consequence less conspicuous.

Imported Elm

White or Soft Elm, *Ulmus americana* L., from Canada and the United States, is light brown to grey in colour, and resembles the common English elm in structure.

Canadian Rock Elm, *Ulmus racemosa* Thomas, is a tough, heavy wood, straight-grained and easy to split and light brown in colour. It is distinguished by the absence of a definite pore-ring. The large pores are sparse and widely scattered and are commonly closed by tyloses.

FALSE ACACIA

FALSE ACACIA, ACACIA, LOCUST—*Robinia pseudoacacia* L.

General Properties.—Heavy or moderately heavy, 40-55 lb. per cu. ft., average about 46 lb.; tough, hard and horny; generally straight-grained; texture coarse. The figure of plain-sawn timber is due to the contrast between the light spring wood and the dark summer wood.

Sapwood narrow, yellowish; heartwood greenish when fresh, turning golden brown later.

Annual rings conspicuous; a ring of large spring wood pores embedded in soft tissue marks the beginning of the season's growth (ring-porous).

Pores of the spring wood large, in a ring one or more rows wide; the pore zone is rendered conspicuous by the surrounding soft tissue and the tyloses, which completely fill the cavity of the pores, except in the outer rings of sapwood. Pores of the summer wood decreasing gradually in size; in the outer zone very much smaller but still distinct under a lens, in scattered groups, often connected by soft tissue to form oblique or tangential chains.

Vessel lines prominent, due to tyloses and surrounding soft tissue.

Soft tissue surrounding the spring wood pores and with them forming a conspicuous band; also round the groups of summer wood pores and often connecting them in short or long diagonal chains. The pores and light coloured soft tissue stand out very clearly on a moistened end surface, in contrast with the dark background.

Rays fine but distinct to the naked eye, conspicuous against the dark ground tissue.

Robinia should not be confused with the true *Acacia*, a large genus of trees and shrubs widely distributed in arid tropical and sub-tropical regions. Some of the best known are *Acacia senegal* Willd., the source of Gum Arabic, the WATTLES of Australia, *Acacia melanoxylon* R.Br., the BLACKWOOD of Australia, and *Acacia arabica* Willd., a very important species in the dry-zone areas of India.

FALSE ACACIA, *Robinia pseudoacacia* L.

Fig. 21

HAZEL, *Corylus avellana* L.

Fig. 22.

HAZEL

Corylus avellana L.

General Properties.—Moderately heavy, 35-45 lb. per cu. ft. ; very flexible ; generally straight-grained ; texture fine and uniform ; cuts with a fairly smooth, bright surface.

Colour white to pale reddish brown ; sapwood and heartwood not distinct.

Annual rings rather obscure on end surface, often curving outwards between the rays ; boundary marked by the slightly denser summer wood zone.

Pores very small, visible only with a lens ; in radial groups and lines, more numerous in the spring wood.

Vessel lines faintly visible to the naked eye.

Soft tissue in a fine line terminating the annual ring, faintly visible with a lens.

Rays of two distinct sizes. The larger (aggregate rays) conspicuous on end surface, lighter than the ground tissue ; irregularly scattered ; usually fairly numerous (compare alder) but sometimes absent over considerable areas ; visible on longitudinal surfaces as lines or flakes commonly exceeding one inch in height but inconspicuous owing to their light colour. The smaller rays very fine, visible only with a lens.

Pith flecks rare or absent.

HOLLY

Ilex aquifolium L.

General Properties.—Heavy or moderately heavy, 45-55 lb. per cu. ft.; grain inclined to be irregular; texture very fine and uniform. Colour greenish white or grey; no distinct heartwood.

Annual rings indistinct; boundary marked by a fine line of denser summer wood.

Pores extremely small, barely visible even with a lens; arranged in radial lines with little variation in size throughout the ring; a loose ring of spring wood pores sometimes marks the beginning of the season's growth.

Vessel lines not distinct to the naked eye.

Soft tissue not visible with a lens.

Rays moderately broad, distinct to the naked eye on all surfaces; very numerous and regular in size on tangential surface.

Pith flecks rare or absent.

Imported Holly

American Holly, *Ilex opaca* Ait., is imported in small quantities. The structure of the wood closely resembles that of the British species.

HOLLY, *Ilex aquifolium* L.

Fig. 23

HORNBEAM, *Carpinus betulus* L.

Fig. 24

HORNBEAM

Carpinus betulus L.

General Properties.—Heavy or moderately heavy, 45-55 lb. per cu. ft. ; hard and tough ; commonly cross-grained, splits with difficulty ; texture fine and uniform.

Colour whitish ; no distinct heartwood.

Annual rings usually distinct ; boundary marked by a narrow band of summer wood, sometimes dotted with small white patches of soft tissue. The wavy outline of the annual rings is characteristic. In the log hornbeam can usually be distinguished from beech by the fluted character of the trunk.

Pores small, sometimes just visible to the naked eye ; distinct with a lens, in short radial lines, uniformly scattered, diminishing in size in the outer part of the ring.

Vessel lines just visible to the naked eye.

Soft tissue in fine broken tangential lines, and in scattered patches at the end of the annual ring, visible with a lens on a moistened end surface.

Rays of two distinct sizes. The larger (aggregate rays) prominent on end surface, lighter than the ground tissue ; usually fairly numerous, irregularly distributed ; faintly visible on tangential surface as long lines slightly darker than the background, commonly exceeding one inch in height ; inconspicuous on radial surface owing to lack of contrast. The smaller rays very fine, distinct only with a lens.

Pith flecks rare or absent.

Imported Hornbeam

Hornbeam imported from the Continent is derived from the same species as that found in Great Britain.

HORSE CHESTNUT

HORSE CHESTNUT—*Aesculus hippocastanum* L.
RED HORSE CHESTNUT—*Aesculus carnea* Hayne.

General Properties.—Light to moderately heavy, 30-40 lb. per cu. ft.; often cross-grained or wavy-grained; texture fine and uniform. Likely to be confused with lime, willow and poplar.

Colour creamy white or yellowish, sometimes tinged with pink; no distinct heartwood.

Annual rings usually distinct; boundary marked by a fine terminal line of soft tissue.

Pores very small, visible only with a lens; mostly single; fairly uniform in size and distribution, rather smaller and less numerous at the outer edge of the ring; a single row of pores sometimes marks the beginning of the season's growth.

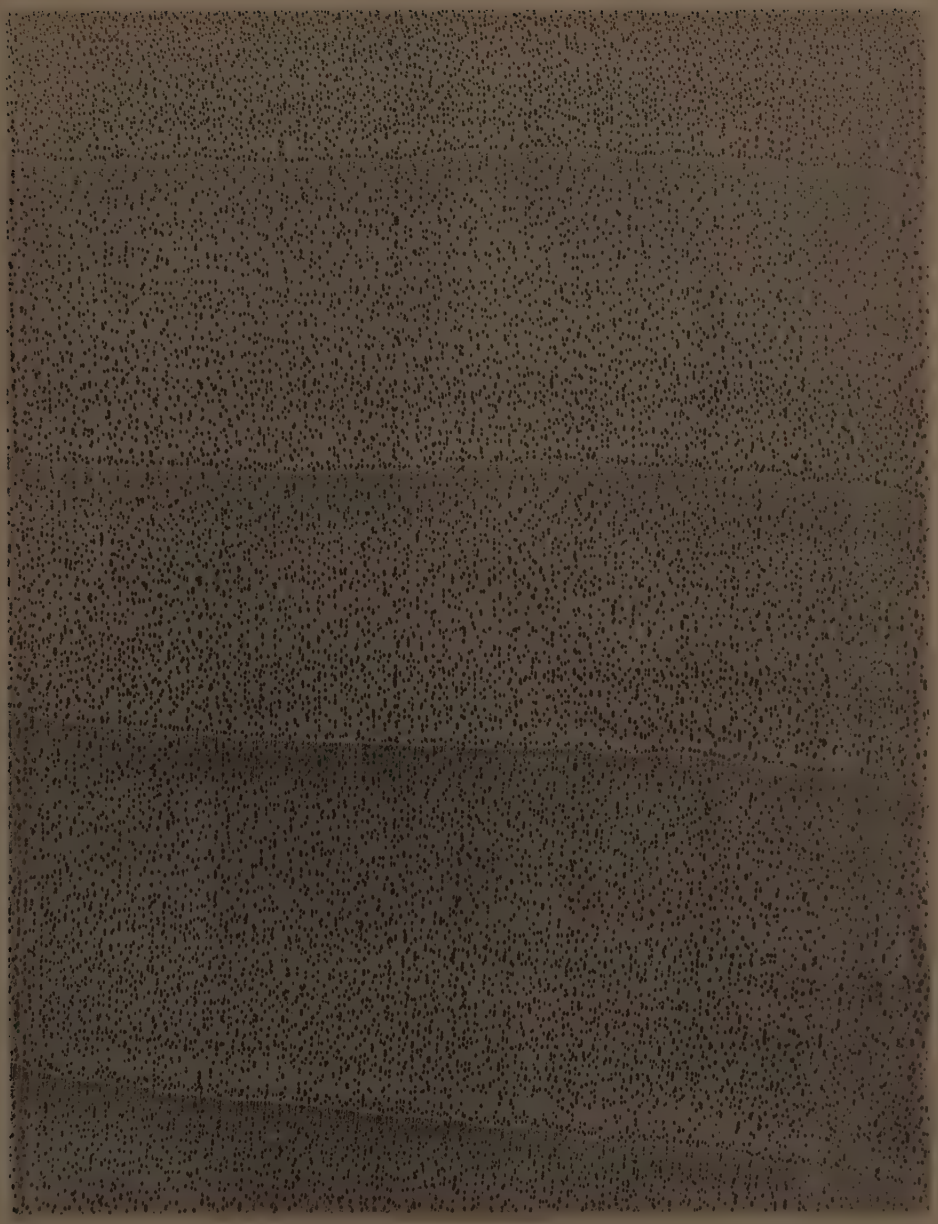
Vessel lines just visible to the naked eye.

Soft tissue faintly visible as a fine line terminating the annual ring.

Rays exceedingly fine and numerous, fairly distinct with a lens, mostly separated by the width of one vessel only (compare lime).

Ripple marks.—On tangential surface the rays are not individually distinct even with a lens but sometimes occur in storied arrangement which produces fine ripple marks (about 60-70 per inch). This is not a constant feature but when present it serves to distinguish horse chestnut from willow and poplar.

Pith flecks rare or absent.



HORSE CHESTNUT, *Aesculus hippocastanum* L.

Fig. 25

LABURNUM, *Laburnum vulgare* PRESL.

Fig. 26

LABURNUM

COMMON LABURNUM—*Laburnum vulgare* Presl.
SCOTCH LABURNUM—*Laburnum alpinum* Presl.

General Properties.—Heavy or moderately heavy, 50-57 lb. per cu. ft.; generally straight-grained; texture fine to medium. Plain-sawn laburnum has a well marked figure owing to the contrast of colour between the bands of soft tissue and the fibres.

Sapwood narrow, yellow, sharply defined from the heartwood which is golden brown when fresh, darkening in time to deep brown.

Annual rings distinct on end surface; a compact ring of spring wood pores embedded in light coloured soft tissue marks the beginning of the season's growth (ring-porous).

Pores of the spring wood small to moderate sized, scarcely distinct without a lens; in a compact ring several rows wide, rendered conspicuous by the soft tissue; open except for occasional gum plugs; diminishing gradually in size from the pore ring outwards (more abrupt in narrow rings). Pores of the summer wood in wavy tangential chains or bands, forming a zig-zag pattern.

Vessel lines not very distinct.

Soft tissue associated with the pores and with them forming chains or bands, very distinct on all surfaces, contrasting with the dense ground tissue. This contrast is much less marked in old specimens.

Rays broad, distinct to the naked eye, as wide as, or wider than the spring wood pores.

LIME

COMMON LIME—*Tilia vulgaris* Hayne, and other species.

General Properties.—Light to moderately heavy, 30-42 lb. per cu. ft.; straight-grained; texture fine and uniform. The wood cuts with a clean, smooth surface in all directions. When green it has a characteristic smell.

Colour variable, white or pale yellow to light brown; no distinct heartwood.

Annual rings usually fairly distinct on end surface; boundary marked by a zone of spring wood pores.

Pores small, barely visible to the naked eye but distinct with a lens; single or in short radial groups; fairly uniform in size and distribution, slightly smaller in the outer zone of the ring.

Vessel lines just visible to the naked eye.

Soft tissue scattered, in numerous fine tangential lines, faintly visible with a good lens.

Rays fine to moderately fine, varying in width; the larger visible to the naked eye, irregularly spaced, usually separated by the width of two or more pores (compare horse chestnut); the smaller barely visible with a lens.

Ripple marks.—A tendency to storied structure in some samples produces very fine ripple marks (about 60 per inch) faintly visible on tangential surface.

Pith flecks absent.

IMPORTED TIMBER

Lime imported from the Continent is derived from the same species as that found in Great Britain.

The structure of North American BASSWOOD, *Tilia americana* L. (*T. glabra* Vent.), and JAPANESE LIME, *Tilia japonica* Simonk., is similar to that of European lime. The name basswood is sometimes applied to American whitewood, *Liriodendron tulipifera* L. (see p. 38).

LIME, *Tilia vulgaris* HAYNE.

Fig. 27

MULBERRY, *Morus nigra* L.

Fig. 28

MULBERRY

COMMON OR BLACK MULBERRY—*Morus nigra* L.
WHITE MULBERRY—*Morus alba* L.

General Properties.—Moderately heavy, 37-45 lb. per cu. ft.; grain irregular; texture coarse; resembling *Robinia* in general appearance.

Sapwood white or yellowish; heartwood yellow or light brown when fresh, darkening with time to dull reddish brown.

Annual rings distinct; boundary clearly marked by a ring of large spring wood pores (ring-porous).

Pores of the spring wood large and conspicuous forming a pore-ring of variable width; often sub-divided; glistening tyloses usually present but not completely filling the cavity; white deposits of lime sometimes present. Pores of the summer wood diminishing gradually in size from the pore-ring outwards, in scattered groups, sometimes linked together in short tangential chains.

Vessel lines distinct.

Soft tissue in a narrow sheath round the pores, sometimes connecting them in lines or chains in the outer part of the annual ring.

Rays moderately broad to broad, distinct to the naked eye, larger than those of *Robinia* but not so wide as the spring wood pores (compare laburnum), lighter than the ground tissue; conspicuous on radial surface.

OAK

COMMON ENGLISH OAK, PEDUNCULATE OAK—*Quercus robur* L. (*Q. pedunculata* Ehrh.).*

SESSILE OAK, DURMAST OAK—*Quercus sessiliflora* Salisb.*

English oak is very variable in quality; the conditions under which the trees grow may possibly affect the character of the timber to a greater degree than any inherent differences between the two species. Generally speaking, pedunculate oak timber is believed to be the more durable, while sessile oak is preferred for some classes of work on account of its milder character. Hybrids between the two species are very common, and the fact that these cannot always be easily distinguished may partly account for the lack of agreement as to the relative merits of the species.

General Properties.—Weight variable, generally about 40-50 lb. per cu. ft.; hardness increasing considerably with age; generally straight-grained; texture coarse. The characteristic silver grain on quarter-sawn boards (radial surface) is due to the broad rays, which provide a ready means of distinguishing oak from chestnut. The figure of plain-sawn timber and rotary-cut veneer is produced by the contrasting zones of spring wood and summer wood.

Sapwood light coloured; heartwood varying from light yellow-brown to a deep warm shade. "Brown oak" is produced by a fungus which deepens the colour of the heartwood in some trees, without apparently affecting its durability or strength.

Annual rings distinct; boundary marked by a ring of large spring wood pores contrasting with the dense summer wood (ring-porous).

Pores of the spring wood large and conspicuous, rounded, forming a pore-ring 1-4 rows wide; generally blocked by tyloses except in the outer rings of sapwood. Transition to summer wood zone abrupt. Pores of the summer wood very much smaller, visible under a lens but too numerous to be readily counted; arranged in radial or fan-shaped masses becoming wider towards the outside of the ring.

Vessel lines very distinct as coarse grooves.

Soft tissue (*a*) embedding the large and small pores and so rendering the groups of summer wood pores distinct on end surface; (*b*) in fine

* Sessile and pedunculate oak were formerly regarded as varieties of *Quercus robur* L. They are now generally treated as distinct species, and the present tendency among botanists is to restrict the name *Quercus robur* to pedunculate oak.

OAK, *Quercus robur* L.

Fig. 29

parallel lines crossing the fibre groups, lighter in colour than the ground tissue.

Rays of two distinct sizes; the larger (compound) rays very broad, conspicuous on end surface and separated by numerous fine rays visible only with a lens. The broad rays appear on plain-sawn or tangential surface as long, slender, spindle-shaped lines, commonly exceeding one inch in height, darker than the ground tissue. On quarter-sawn or radial surface they appear as lustrous bands or flakes (silver grain).

OTHER SPECIES OF BRITISH-GROWN OAK

Evergreen or Holm Oak—*Quercus ilex* L.

A native of southern Europe and Asia, grown in this country as an ornamental tree. The wood is very hard and heavy and difficult to work, light brown to reddish in colour, with no sharp distinction between sapwood and heartwood. The wood of this and other evergreen oaks can usually be distinguished from that of the deciduous oaks by the absence of a definite pore-ring (fig. 31). Growth rings are generally indistinct, marked by a line of denser wood. The pores are small to moderate sized, some at least clearly visible to the naked eye, in loose radial lines, often continuous across several growth rings. The compound rays are extremely broad and conspicuous on all surfaces.

In some, possibly abnormal, specimens the rings are marked by a distinct zone of large spring wood pores, the structure of the wood approaching that of red oak or Turkey oak.

Turkey Oak—*Quercus cerris* L.

A native of southern Europe and Asia Minor. The timber is of inferior quality to English oak, hard and heavy and takes a good polish but is difficult to season, and not durable. The sapwood is broader and the heart a redder brown than in English oak. The structure of the wood resembles that of American red oak except that the spring wood pores are smaller and form a less distinct ring.

IMPORTED OAK

European Oak.—Oak timber imported from the Continent is derived from the same species as English oak. Certain grades of Continental oak, with special qualities such as mildness and freedom from warping, have become associated with certain shipping ports and countries of origin. These local varieties, however, cannot be distinguished with certainty by examination of their structure.

American Oak.—The deciduous oaks of North America are divided into two groups, the White Oaks and the Red Oaks. The timber of the two groups is distinguished by differences in structure as well as technical properties. White oak, on account of its better seasoning and working qualities, is superior to red oak.

A certain amount of confusion exists in the English market as regards North American oak owing to the use of the terms "northern" and "southern." Northern oak is largely derived from the Appalachian hardwood region, while southern oak is furnished by the southern hardwood area draining into the Mississippi and the Gulf of Mexico. Northern oak more closely resembles English and is, on the whole, milder and less liable to warp than the fast-grown timber of the southern States. The practice of shipping southern oak from northern ports has, however, deprived these names of much of their significance. The present tendency is to use the term "northern" for white oak, and "southern" for red, but it should be borne in mind that the southern hardwood region includes tracts of country which, on account of their altitude and exposure, produce timber almost indistinguishable from northern grown.

AMERICAN WHITE OAK—*Quercus alba* L. and other species.

The sapwood is white; the heartwood pale to medium grey-brown, sometimes with a slight reddish tinge. The structure of the wood is similar to that of English oak. The wide range over which it is grown is reflected in the variation of ring-width, texture and working qualities. In the white oaks of the southern States, where growth is rapid, the transition from large spring wood pores to small summer wood pores is more gradual, approaching the arrangement found in the red oaks. The wood of the two groups can, however, be easily separated on the number and character of the summer wood pores. In white oak these are very small, visible with a lens but too numerous to be readily counted, while in the red oak (see below) they are larger and relatively sparse. A further distinguishing feature is the height of the rays as seen on a plain-sawn or tangential surface. In white oak these are frequently several inches in height while those of red oak rarely exceed one inch.

AMERICAN RED OAK—*Quercus borealis* Michx. f. (*Q. rubra* Sudw.) and other species.*

The sapwood is white; the heartwood usually pale reddish brown, but sometimes resembles white oak in colour. The structure of the wood differs from white oak and English oak principally in the character of the pores. The large, oval spring wood pores are typically crowded in a wide pore-ring with a gradual decrease in size outwards. The summer wood pores are individually distinct under a lens, few enough to be counted, and are arranged in fairly definite radial rows (fig. 30). In narrow growth rings the transition in size from spring to summer wood pores is more abrupt and the small pores tend to be arranged in fan-shaped groups. The height of the rays as seen on plain sawn or tangential surface is rarely more than one inch.

* The name *Quercus rubra* is applied to two or more distinct species of red oak by recent American writers. To avoid confusion it seems best to discontinue the use of this name and to adopt the name *Q. borealis* Michx. f. for the northern red oak and *Q. falcata* Michx. for the southern red oak.

In most samples of red oak the rings are comparatively wide and are more conspicuous than in other kinds of oak owing to the greater number and more open character of the large spring wood pores, tyloses being comparatively sparse. This gives the wood a coarser appearance than that of white oak or English oak.

JAPANESE OAK—*Quercus grosseserrata* Bl. and other species.

Most of the Japanese oak imported into Great Britain belongs to the same group as English oak and American white oak (fig. 31). The timber is of uniformly good colour, light brown tinged with grey rather than red, mild and easy to work and suitable for interior rather than constructional purposes.

OTHER IMPORTED TIMBERS KNOWN AS OAK

The SILKY OAKS of Australia are the product of *Cardwellia sublimis* F.v.M. and *Grevillea robusta* A. Cunn. The woods resemble true oak in having very broad rays which produce a conspicuous silver grain on quarter-sawn boards. They are moderately hard and heavy, brown to reddish brown in colour. The rays are connected by short arcs of soft tissue, from which the pores appear to hang as pendants (fig. 34). True growth rings are not generally apparent but the alternate zones of soft tissue and fibres produce an appearance rather similar to the the rings in very slow grown oak.

The Australian SHE OAKS (species of *Casuarina*) also possess a well marked silver grain. The wood is brown to reddish brown, very hard and heavy, without distinct growth rings ; the pores are small and in loose irregular lines (fig. 33). The rays are extremely variable in size, from fine to very broad, the broad rays irregular in distribution.

TASMANIAN OAK (Tasmanian ash) is probably furnished by more than one species, *Eucalyptus delegatensis* R.T.B., *E. obliqua* L'Hérit. and *E. regnans* F.v.M. It is a strong resilient timber, rather close-textured with a straight grain. Pale coloured when fresh, it tones down to a light oak shade. While it has no outstanding silver grain, owing to the absence of large rays, its general appearance is not unlike plain-sawn oak. The growth rings are usually distinct owing to the contrast in density between alternate zones. The pores are clearly visible to the naked eye, uniform in size, and forming the obliquely radial lines characteristic of *Eucalyptus* woods generally (" herring-bone " pattern) (fig. 35). They are usually crowded in the early part of the ring, sometimes approaching a ring-porous arrangement. VICTORIAN OAK is stated to be derived from one of the species which furnish Tasmanian oak.

A table and illustrations of the principal features by which woods known as oak can be distinguished are given overleaf.

THE PRINCIPAL FEATURES BY WHICH WOODS KNOWN AS OAK CAN BE DISTINGUISHED

	Growth rings.	Pore size.	Ray size.	Pore arrangement.
European, Japanese and American white oak.	**Distinct, ring-porous.**	Large and conspicuous, **changing abruptly to very small and closely packed in summer wood.**	(*a*) Very broad, exceeding 1 inch in height. (*b*) Fine.	Fan-shaped radial groups in summer wood.
Turkey oak and American red oak.	**Distinct, ring-porous.**	Large and conspicuous in spring wood, **decreasing gradually to small and well separated in summer wood.**	(*a*) Very broad, less than 1 inch in height. (*b*) Fine.	Radial lines in summer wood.
Tasmanian oak	Usually distinct, marked by dark band. Diffuse-porous.	Moderate to large	**Fine.**	**Oblique lines,** "herring bone" pattern.
Silky oak ..	Indistinct ..	Moderate	(*a*) Very broad .. (*b*) Very fine, scarcely visible, even with lens.	**Concentric arcs,** associated with soft tissue.
Evergreen oak ..	Inconspicuous ..	Small to moderate	(*a*) Very broad .. (*b*) Fine.	**Radial lines,** often continuing across several growth rings.
She oak	Indistinct or absent.	Small	**All gradations in size** from fine to very broad.	**Loose irregular** radial lines.

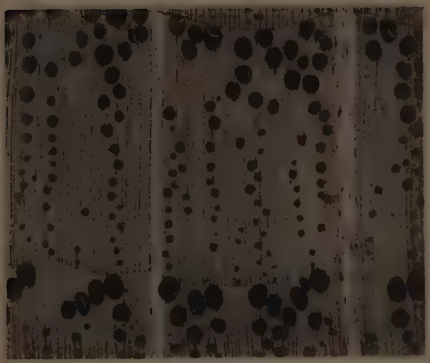


Fig. 30 RED OAK,
Quercus rubra L.

Fig. 31 JAPANESE OAK,
Quercus sp.

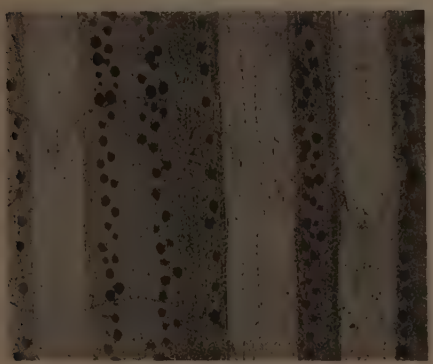


Fig. 32 EVERGREEN OAK,
Quercus ilex L.

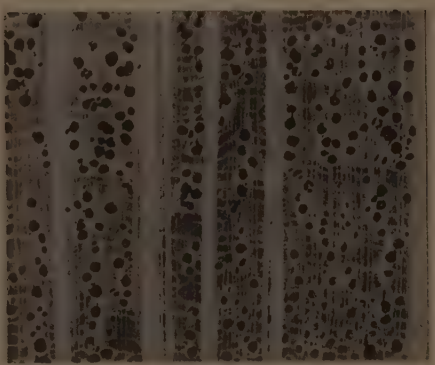
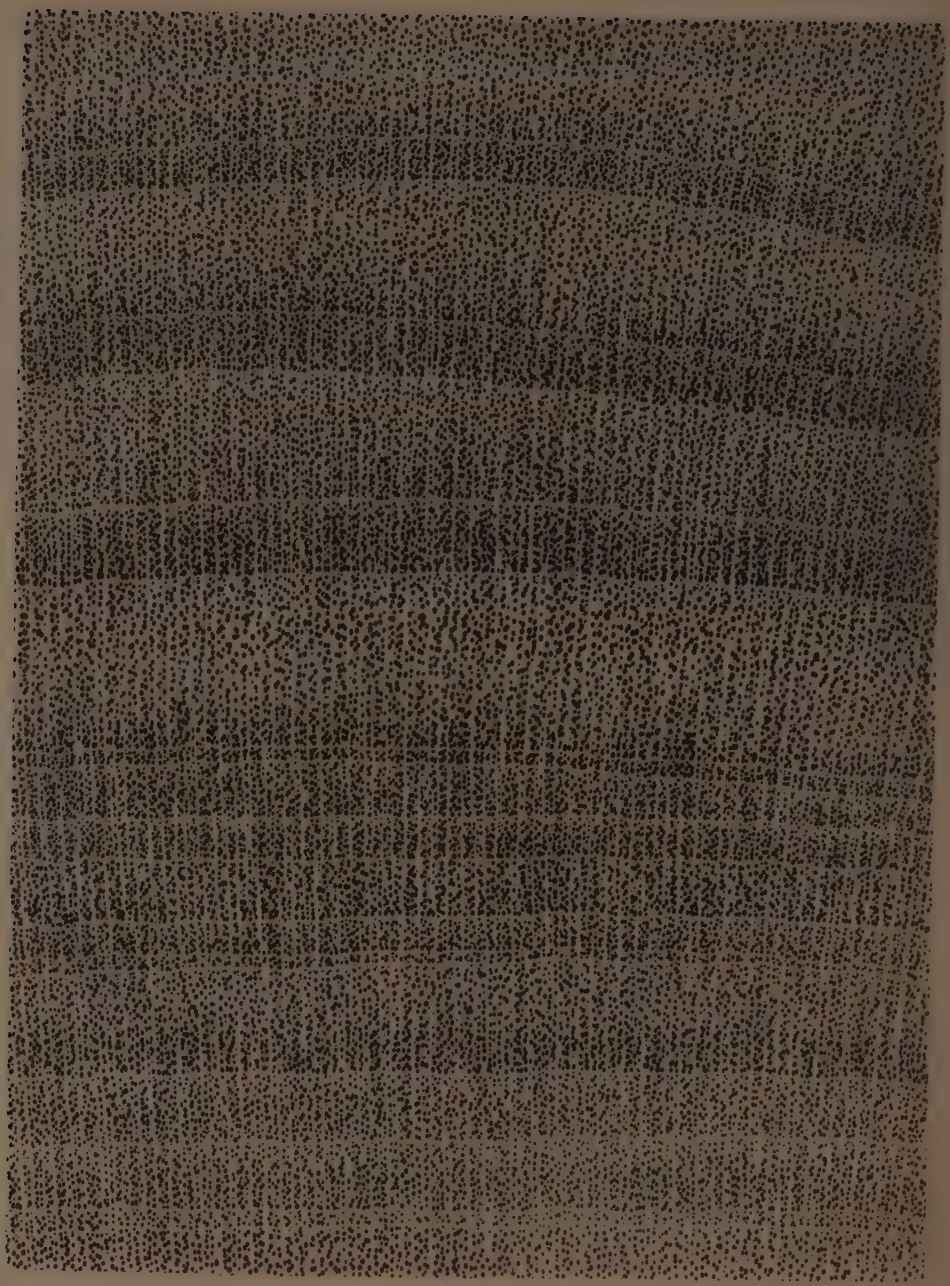


Fig. 33 SHE OAK,
Casuarina torulosa DRYAND.

Fig. 34 SILKY OAK,
Grevillea robusta A.CUNN.

Fig. 35 TASMANIAN OAK,
Eucalyptus delegatensis R.T.B.



PEAR, *Pyrus communis* L.

Fig. 36

PEAR

Pyrus communis L.

General Properties.—Moderately heavy, 40-50 lb. per cu. ft.; tough; grain inclined to be irregular; texture fine and uniform; cuts equally well in all directions.

Colour pale reddish brown; usually no distinct heartwood, but the centre of old trees is sometimes darker.

Annual rings distinct to indistinct; boundary marked by a narrow band of denser summer wood.

Pores small to very small, visible only with a lens; mostly single, fairly uniform in size and distribution, slightly smaller and distinctly less numerous in the late summer wood.

Vessel lines distinct only with a lens.

Rays fine, not individually distinct without a lens; about the same width as the pores; inconspicuous on radial surface as small flakes, darker than the ground tissue.

Pith flecks sometimes present.

The wood of APPLE, *Pyrus malus* L., closely resembles pear in structure and general properties. It is generally considered inferior to pear. The sapwood is distinct from the reddish brown heartwood. Wood from old trees is often streaked with darker zones.

There are several other woods of the same family (Rosaceae) as the apple, pear and cherry which are very similar in general character. Owing to their small size or scarcity they are not of great economic importance, though they are occasionally used for purposes similar to those of pear.

Of these, the HAWTHORN, *Crataegus oxyacantha* L., produces a very hard, heavy wood, distinctly pinker in colour than pear or apple but essentially similar in structure. The trunk is typically irregular, often twisted and deeply furrowed, and is, in consequence, of comparatively little value as timber.

In the ROWAN or MOUNTAIN ASH, *Pyrus aucuparia* Gaertn. (*Sorbus aucuparia* L.), the annual rings are clearly marked by broad zones of denser summer wood rather like those of a conifer. Pith flecks are common; these are often irregularly fringed on the outer edge. The sapwood is white or reddish white, the heartwood reddish brown.

The wood of the SERVICE TREES, *Pyrus torminalis* Ehrh. and *Pyrus sorbus* Gaertn., and the WHITEBEAM, *Pyrus aria* Ehrh., is very similar to that of the rowan. The broad zone of summer wood is not so clearly marked.

PLANE

LONDON PLANE—*Platanus acerifolia* Willd.

General Properties.—Light to moderately heavy, 30-45 lb. per cu. ft.; commonly cross-grained; texture fine and uniform; somewhat similar to sycamore and beech; distinguished from these by the character of the rays, which are very prominent on quarter-sawn timber. Those of sycamore are in comparison inconspicuous on a quarter-sawn or radial surface. The broad rays of beech are more widely spaced and appear very bright on an end surface.

Colour ranging from dirty white in the sapwood to brown or reddish brown in the heart; no sharp demarcation between sapwood and heartwood.

Annual rings usually fairly distinct; boundary marked by a lighter coloured band of summer wood with few pores.

Pores small, barely visible to the naked eye, distinct only with a lens; uniform in size and crowded throughout the annual rings, except in the narrow terminal band of summer wood, producing a rather spongy appearance under a lens.

Vessel lines distinct only with a lens.

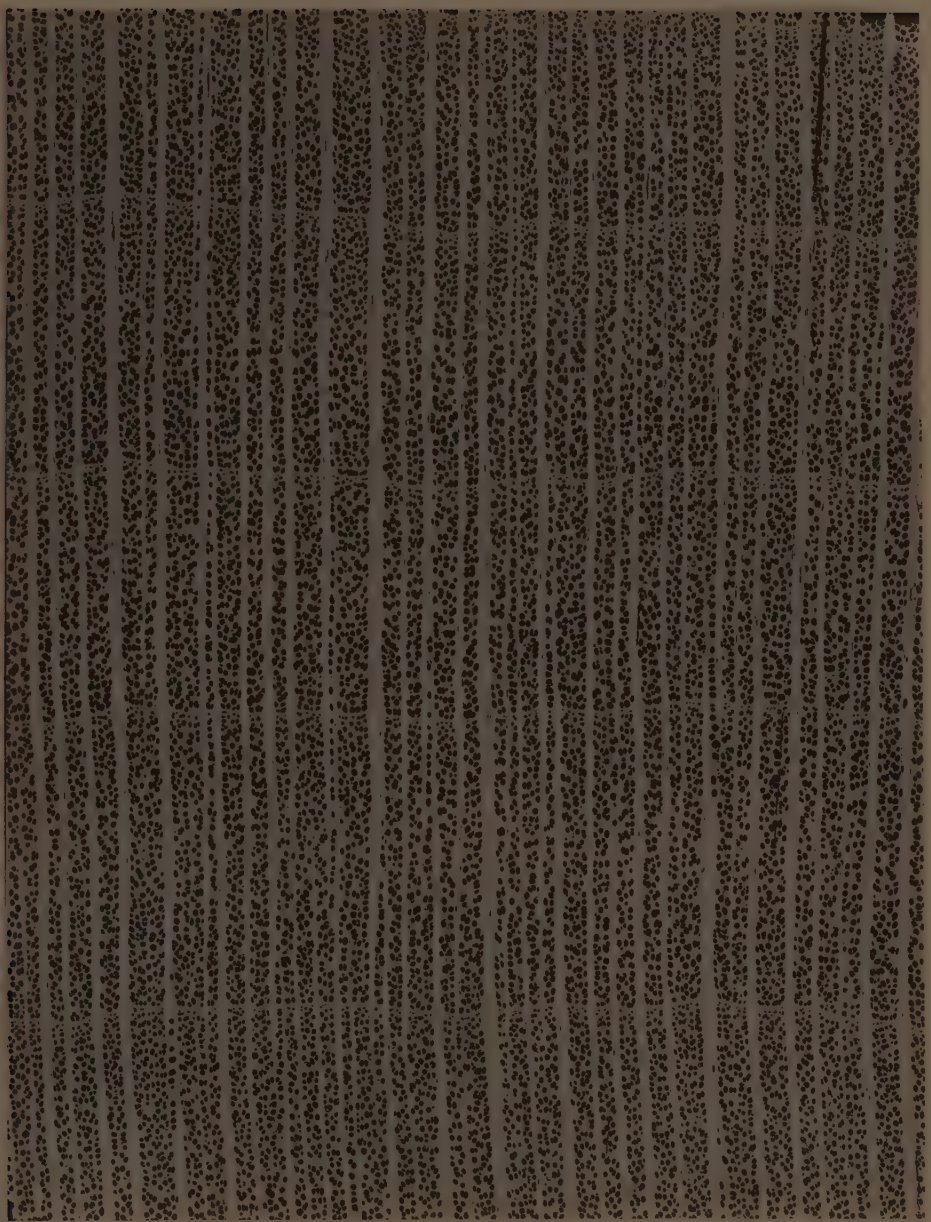
Soft tissue not visible with a lens.

Rays broad and abundant, wider than the pores, occupying about one-third of the end surface but not very conspicuous on account of their lack of lustre. Prominent on quarter-sawn or radial surface as reddish brown flakes, one-eighth of an inch or more in height.

Pith flecks absent.

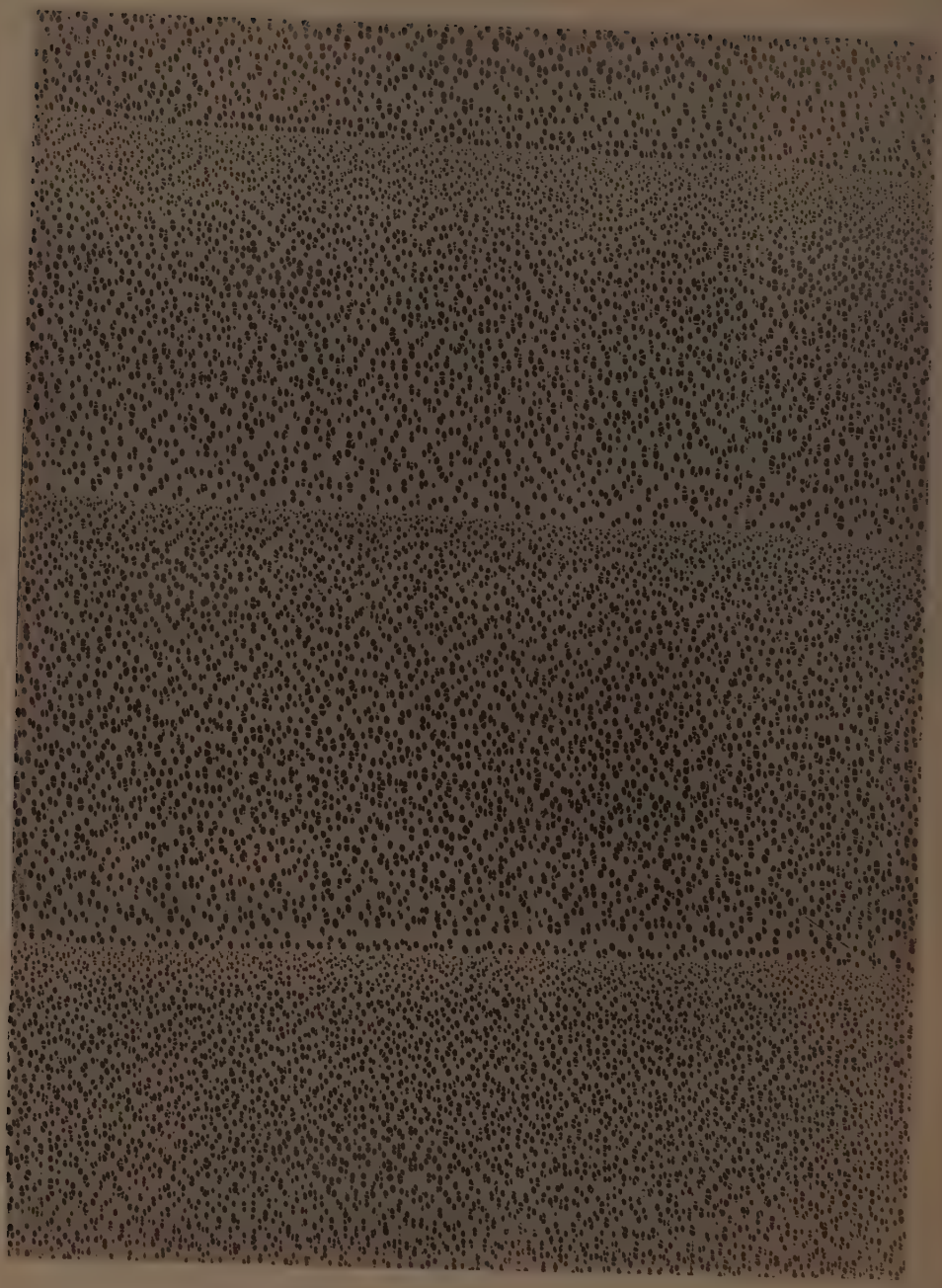
The tree known as plane in Scotland is the English sycamore, *Acer pseudoplatanus* L.

The woods of the AMERICAN PLANE, *Platanus occidentalis* L. (called SYCAMORE or BUTTONWOOD in the United States and Canada), and the ORIENTAL PLANE, *Platanus orientalis* L. (which is sometimes imported from the Continent), are similar to that of the London plane.



PLANE, *Platanus acerifolia* WILLD.

Fig. 37



POPLAR, *Populus serotina* HARTIG.

Fig. 38

POPLAR*

ASPEN—*Populus tremula* L.
BLACK POPLAR—*Populus nigra* L. and other species.
WHITE POPLAR—*Populus alba* L. and other species.

The various species and hybrids of poplar grown in the British Isles fall into three main groups as given above. Species which cannot be distinguished by their minute anatomy may nevertheless differ in such general characters as ring-width, dimensions and working qualities, owing to their habits of growth.

The true BLACK POPLAR has been largely replaced by the faster growing BLACK ITALIAN POPLAR, *Populus serotina* Hartig. This timber is obtainable in large sizes and is of better quality than that of the true black poplar. The LOMBARDY POPLAR, a variety of *Populus nigra*, is of practically no value as a timber tree, the wood being very coarse and knotty.

The ASPEN is especially characteristic of northern latitudes. In the British Isles it attains its best development in the highlands of Scotland.

WHITE POPLAR, or ABELE, and GREY POPLAR, *Populus canescens* Sm., grow to a larger size than aspen and produce timber which, when clean and moderately slow grown has been found suitable for the same purposes. The heartwood of these two species is distinctly reddish.

There are, in addition to the above, a number of hybrid poplars which are being grown experimentally. It is not possible at present to assess the relative value of their timber. The structure of the wood of all the above is so similar that a single description applies generally.

General Properties.—Light, 23-35 lb. per cu. ft.; straight-grained; texture fine and uniform, rather woolly; withstands friction and does not splinter easily; finishes with a dull surface; closely resembles willow, from which it can only be distinguished with certainty by microscopic examination.

Sapwood and heartwood not usually distinct; colour white to light brown or grey, often streaked; white poplars sometimes have reddish heartwood.

Annual rings usually distinct on a clean-cut end surface; boundary marked by a fine line of soft tissue and a denser band of late summer

* An account of the character and uses of poplar timber can be found in Forestry Commission Bulletin No. 5, "Poplars." H.M. Stationery Office, 1923, price 1*s.* 6*d.* net.

wood, which contrasts with the more open texture of the following spring wood.

Pores small, barely visible to moderately distinct; very numerous; often in radial groups (compare willow), and, in wide rings, in loose festoons or diagonal lines; fairly uniform in size, diminishing in the summer wood; crowded at the beginning of the annual ring.

Vessel lines visible as fine scratches.

Soft tissue faintly visible as a fine line terminating the annual ring.

Rays very fine and numerous, indistinct even with a lens.

Pith flecks sometimes present, more common in aspen than in the other species.

Imported Timber

Supplies of aspen are imported from the Baltic.

Canadian Aspen is *Populus tremuloides* Michx. The Balsam Poplar or Cottonwood of Western Canada, *Populus trichocarpa* Torr. and Gray, is imported in the form of plywood. Cottonwood from eastern North America is *Populus deltoides* Marsh.

Yellow Poplar is one of many names applied to *Liriodendron tulipifera* L., also known as American Whitewood, Canary Whitewood, Tulip Tree (*not* Tulipwood), and sometimes as Basswood. This last name, however, properly belongs to North American lime wood (p. 28). The wood is mild and soft, of about the same average weight as poplar; the colour widely variable, from clear yellow to green, brown or purple, often streaked A greenish yellow tint with a satin lustre is usually characteristic of a freshly cut surface but on exposure the wood becomes dulled and bleached. Annual rings, marked by a lighter coloured line of terminal soft tissue, are sometimes indistinct in narrow-ringed wood (fig. 14). The rays are fine but distinct without magnification.

SYCAMORE, *Acer pseudoplatanus* L.

Fig. 39

SYCAMORE AND MAPLE

SYCAMORE, GREAT MAPLE (PLANE in Scotland)—*Acer pseudoplatanus* L.

General Properties.—Moderately heavy, 35-45 lb. per cu. ft.; generally straight-grained; texture fine and uniform.

Colour white or yellowish, lustrous; sapwood and heartwood not usually distinct. Sycamore wood is sometimes artificially coloured grey and marketed as HAREWOOD or SILVER-GREY WOOD.

Annual rings usually distinct on all surfaces; boundary on end surface marked by a fine line of light coloured soft tissue; little contrast between spring and summer wood.

Pores small, barely visible to the naked eye but distinct with a lens; single or in short radial groups; well separated and evenly distributed, with little variation in size throughout the ring.

Vessel lines visible as fine scratches.

Soft tissue in a fine line terminating the annual ring.

Rays moderately broad, distinct on end surface as clear bright lines, slightly broader than the pores; producing a satin sheen on quarter-sawn or radial surface.

Pith flecks rare or absent.

OTHER BRITISH SPECIES

The wood of the FIELD MAPLE, *Acer campestre* L., and the NORWAY MAPLE, *Acer platanoides* L., closely resembles that of sycamore, but the rays are smaller, more numerous and more uniform in size. Field maple often contains curled and mottled timber with a bird's-eye figure. Pith flecks are sometimes present.

IMPORTED TIMBER

North American HARD or SUGAR MAPLE, *Acer saccharum* Marsh., is a harder, denser wood than sycamore, taking a fine lustrous finish. The well-known mottled bird's-eye maple is mostly furnished by this species. The heartwood is light reddish brown with darker lines, marking the annual rings, very distinct on longitudinal surfaces. The rays on end surface are inconspicuous owing to their dark colour; some are broader than the pores, others fine and visible only with a lens. On quarter-sawn or radial surface they show as small reddish brown flakes against the lighter background.

AMERICAN SOFT MAPLE is mainly the product of two species, *Acer saccharinum* L. (*A. dasycarpum* Ehrh.), and *Acer rubrum* L. The wood is generally lighter than hard maple, rather darker in colour and finishes

with a comparatively dull surface. The rays on end surface are slightly smaller and more uniform in size. Pith flecks, which are seldom present in hard maple, are common in the wood of the soft variety.

The wood known as sycamore in the U.S.A. is *Platanus occidentalis* L. (see under Plane, p. 36).

Queensland Maple, *Flindersia chatawaiana* Bailey, is a light pinkish brown, slightly aromatic wood, generally straight-grained but sometimes figured. The pores are moderately large, visible without magnification, single or in groups of 2-4 (fig. 12). The fine rays appear distinctly reddish on an end surface. Growth rings are somewhat indistinctly marked by zones with more numerous pores.

WALNUT

English Walnut—*Juglans regia* L.

General Properties.—Moderately heavy, generally about 38-48 lb. per cu. ft.; texture uniform, fine to medium. The figure of straight-grained timber is produced by irregular dark brown or black streaks. The mottled wood obtained from burrs is highly valued for veneers.

Sapwood pale brown or grey; heartwood fawn coloured to deep brown or black, streaked.

Annual rings distinct to indistinct; sometimes with a tendency to be ring-porous.

Pores moderate sized, clearly visible to the naked eye; mostly single; rather widely scattered except in narrow rings; larger in the spring wood zone, diminishing gradually in size towards the outer part of the season's growth and so defining the annual rings. Glistening tyloses generally present.

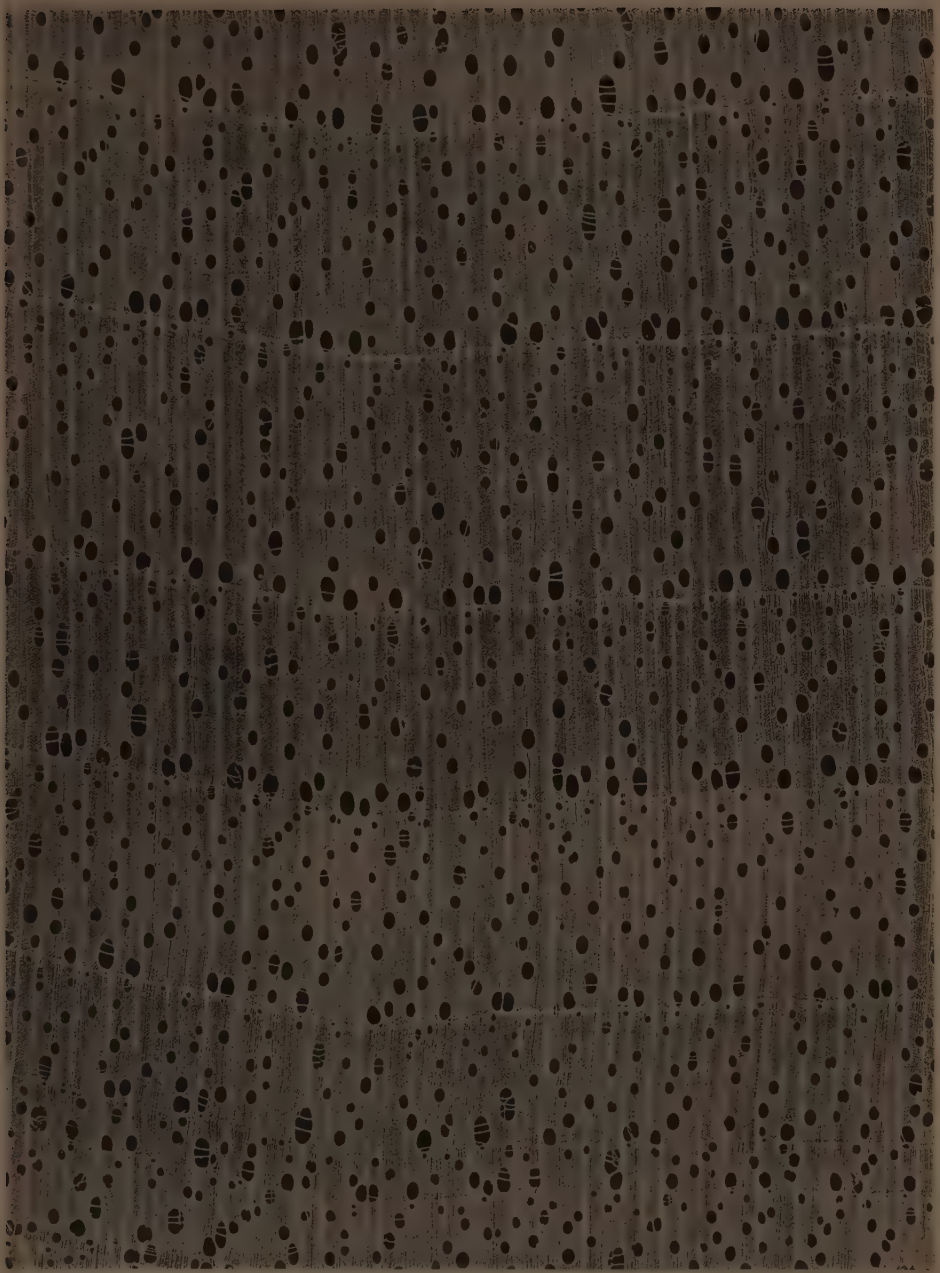
Vessel lines distinct as dark lines or grooves.

Soft tissue in numerous very fine tangential lines at right-angles to the rays, visible with a lens; also in a fine line terminating the annual rings, sometimes obscure.

Rays fine, distinct or moderately distinct to the naked eye.

Imported Walnut

The walnut is widely distributed over Europe and Asia. The timber is imported under a variety of names denoting the country of origin.



WALNUT, *Juglans regia* L.

Fig. 40

French, Italian, Circassian, Spanish, Turkish and Persian walnut are all the product of *Juglans regia*. Colour, figure and texture, the characters which distinguish the different varieties, often vary considerably in different samples of timber from the same locality.

American Black Walnut, *Juglans nigra* L., resembles European walnut in structure but is typically of a darker and more uniform colour. It varies from a light chocolate brown to a deep purplish shade. Black walnut has been grown successfully in England and on the Continent. Timber so produced retains the characteristic colour of American walnut.

American White Walnut or Butternut, *Juglans cinerea* L., resembles black walnut in structure but is a lighter, softer wood, pale yellow brown in colour with darker streaks.

Other Timbers Known as Walnut

Satin Walnut, *Liquidambar styraciflua* L., also known as Red Gum (heartwood), Sap Gum and Hazel Pine (sapwood), is imported from the United States. It resembles walnut only in the presence of irregular dark streaks in the reddish brown heartwood. The sapwood is white or pinkish. The pores are very small and numerous, visible only with a lens (fig. 44), the growth rings very obscure. Gum ducts are sometimes present.

African Walnut, or Anamomilla, *Lovoa klaineana* Pierre, is commonly shipped from West African ports with consignments of African mahogany. It is related to the mahoganies (family Meliaceae) and closely resembles them in grain and structure. The heartwood is walnut brown with dark markings due to gum veins, which very commonly appear as concentric arcs on end surface and as long streaks on the faces of boards. The pores are evenly distributed, distinct to the unaided eye, with frequent deposits of dark gum (fig. 43). Soft tissue is variable, in some samples fine continuous lines are visible at irregular intervals, in others these cannot be distinguished. The rays are fine, sometimes just visible to the naked eye.

East Indian Walnut or Kokko, *Albizzia lebbek* Benth., exported from the Andamans, is a hard, heavy wood which bears a superficial resemblance to true walnut. It is dull brown in colour with darker streaks. Growth rings are sometimes marked by a fine continuous line of soft tissue. The pores are large, rather sparse, often in oblique lines, and are rendered conspicuous by a halo of light coloured soft tissue (fig. 41). This also makes the vessel lines very prominent on longitudinal surfaces and gives the wood a rather coarse appearance. Small supplies of true walnut, *Juglans regia* L., are also exported from India.

Queensland Walnut, *Cryptocarya palmerstoni* White (*Endiandra palmerstoni* Bailey) and possibly other species, is a moderately heavy wood, pale chocolate brown in colour and possessing a peculiar, unpleasant odour. A fine wavy figure is often present and in addition the wood is sometimes streaked as in true walnut. The pores are slightly smaller than those of true walnut, just visible without magnification, and

uniformly scattered (fig. 42). Tangential lines of soft tissue, up to 20 per inch of radius, are visible to the naked eye on a clean-cut end surface and sharply defined under a lens.

THE PRINCIPAL FEATURES BY WHICH WOODS KNOWN AS WALNUT CAN BE DISTINGUISHED

	Growth rings.	Pores.	Soft tissue.
Walnut	**Distinct,** marked by larger spring wood pores.	Moderate to small, larger in spring wood.	Numerous very fine short lines.
Satin walnut ..	Indistinct	**Very small,** very numerous.	Absent.
East Indian walnut.	Indistinct or absent.	Large	**Encircling the pores.**
Queensland walnut.	Indistinct or absent.	Moderate to small	**Fairly numerous tangential lines, sharply defined.**
African walnut ..	Indistinct or absent.	Moderate to small	**Occasional tangential lines, not sharply defined.**

Fig. 41 EAST INDIAN WALNUT,
Albizzia lebbek BENTH.

Fig. 42 QUEENSLAND WALNUT.
Cryptocarya palmerstoni BAILEY.

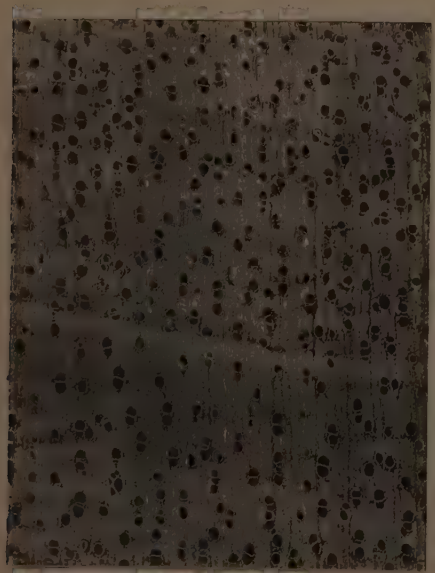
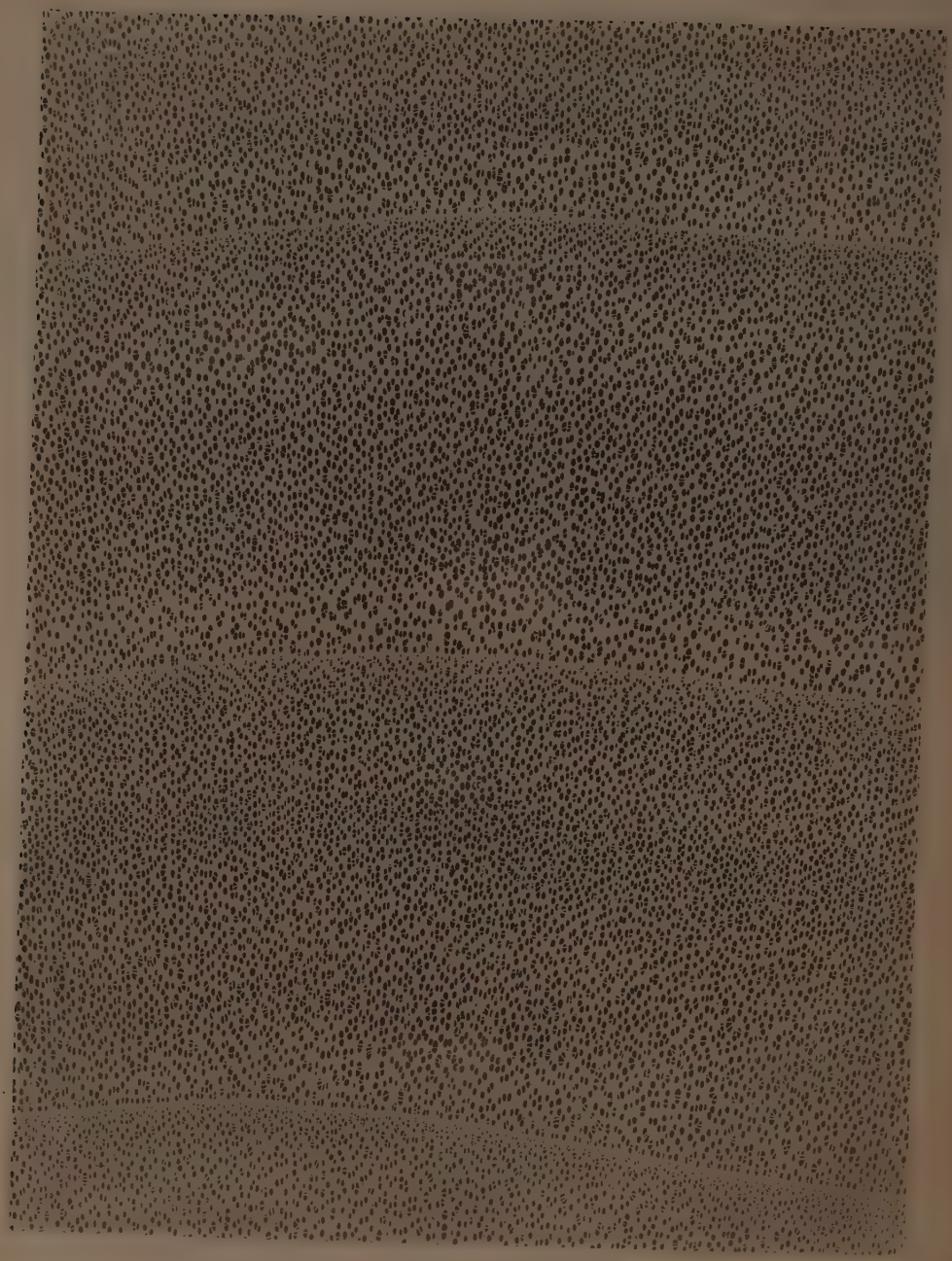


Fig. 43 AFRICAN WALNUT,
Lovoa klaineana PIERRE.

Fig. 44 SATIN WALNUT.
Liquidambar styraciflua L.



WILLOW, *Salix fragilis* L.

Fig. 45

WILLOW

CRICKET BAT WILLOW, CLOSE-BARK WILLOW—*Salix coerulea* Sm.
WHITE WILLOW, COMMON WILLOW—*Salix alba* L.
CRACK WILLOW, OPEN-BARK WILLOW—*Salix fragilis* L. and other species.

Of the numerous native species the most valuable timber is produced by the cricket bat willow. This grows exceedingly rapidly under favourable conditions, producing rings up to one inch in width. It combines the qualities of a wide sapwood with light weight and ability to resist compression without splitting. The other species of willow are not so fast-growing and generally produce a heavier timber.

General Properties.—Light, 25-40 lb. per cu. ft., average about 30 lb.; straight-grained; texture fine and uniform; closely resembles poplar, from which it can only be distinguished with certainty by microscopic examination.

Sapwood white; heartwood light reddish brown. The heartwood of willow is generally redder than that of poplar and lacks the greyish streaks characteristic of the latter, but this colour distinction is not always reliable. The width of the sapwood varies considerably according to species, being particularly wide in *Salix coerulea* and *S. alba*.

Annual rings usually distinct on a clean-cut end surface; boundary marked by a fine line of soft tissue and a denser band of late summer wood which contrasts with the more open texture of the following spring wood.

Pores small, sometimes just visible to the naked eye but not individually distinct without a lens, very numerous; mostly single (compare poplar), also in short radial groups; fairly uniform in size and distribution, smaller in the outer zone of summer wood.

Vessel lines visible as fine scratches.

Soft tissue faintly visible as a fine line terminating the annual ring.

Rays very fine and numerous, indistinct even with a lens.

Pith flecks commonly present.

KEY TO THE IDENTIFICATION OF THE COMMON BRITISH HARDWOODS

In the following key the end surface or cross section is always referred to unless otherwise stated. It is most important that the surface should be cut perfectly smooth with a sharp knife or chisel. It is useless to examine a large roughly planed or sand-papered surface for the finer structural details. A small area carefully prepared will generally show all that is required. Moistening the surface often brings out particular features, while others are clearer when the wood is dry.

The headings of the key are arranged in pairs, so that at each stage there is a choice between two possibilities. These two alternatives are given the same number on the left-hand side. For example, under 1 the wood is either ring-porous or diffuse-porous. The figure on the right indicates the next pair of alternatives ; thus for a diffuse-porous wood the next step, 8, is to decide whether or not the pores are individually distinct to the naked eye. If they are distinct, the wood is walnut, if not, the next step is 9. If there is any doubt as to which alternative to follow, always try both.

1. Pores of the spring wood in a conspicuous ring or band, *ring-porous* woods 2
1. Pores of the spring wood not in a conspicuous ring or band, *diffuse-porous* woods 8
2. Pores of the summer wood in radial lines or groups 3
2. Pores of the summer wood not in radial lines or groups, but scattered or in tangential lines, chains or bands 4
3. Rays of two distinct sizes, the larger very broad and conspicuous .. **Oak**
3. Rays all very fine and inconspicuous .. .. .. **Sweet chestnut**
4. Pores of the summer wood single or in scattered groups, sometimes joined by soft tissue in the outer part of the annual ring to form tangential lines or chains 5
4. Pores of the summer wood in distinct wavy tangential bands or chains 7
5. Wood white or pale coloured, not yellow. Rays barely visible to the naked eye .. .. **Ash**
5. Wood yellow to dark brown. Rays distinct to the naked eye .. 6
6. Tyloses completely filling the pores. Soft tissue very conspicuous against the dark coloured background **False acacia**
6. Tyloses not completely filling the pores. Soft tissue comparatively inconspicuous .. .. **Mulberry**
7. Rays as wide as, or wider than, the spring wood pores .. .. **Laburnum**
7. Rays not so wide as the spring wood pores .. .. **Elm**
8. Pores individually distinct to the naked eye .. .. **Walnut**
8. Pores not individually distinct to the naked eye 9
9. Rays of two distinct sizes, the larger broad and conspicuous 10

9. Rays not of two distinct sizes 13

10. Pores in radial rows. Broad rays faintly visible on tangential surface as long lines, slightly darker than the background.. 11

10. Pores not in radial rows. Broad rays clearly visible on tangential surface as short dark lines .. .. .. **Beech**

11. Wood white, hard and heavy .. .. **Hornbeam**

11. Wood pale coloured to light reddish brown, soft and light or only moderately hard and heavy 12

12. Broad rays fairly numerous. Wood moderately hard and firm to cut. Pith flecks not so common as in alder **Hazel**

12. Broad rays comparatively sparse. Wood soft and woolly to cut. Pith flecks fairly common .. .. **Alder**

13. Woods very fine textured; pores barely visible, even with a lens .. 14

13. Woods fine to medium textured; pores distinctly visible with a lens.. 15

14. Rays moderately broad, distinct to the naked eye .. **Holly**

14. Rays very fine, not distinct to the naked eye .. .. .. **Box**

15. Rays individually distinct to the naked eye 16

15. Rays not individually distinct to the naked eye.. 18

16. Rays more than twice as wide as the pores .. .. **Plane**

16. Rays less than twice as wide as the pores 17

17. Wood white or yellowish. Annual rings marked by a white line. Pores mostly open .. .. **Sycamore**

17. Wood light brown or reddish. Annual rings marked by a zone of spring wood with abundant pores. Pores often plugged with dark coloured gum .. .. **Cherry**

18. Woods hard and moderately heavy 19

18. Woods soft and moderately light 20

19. Wood pale coloured, not red; lustrous .. .. **Birch**

19. Wood distinctly reddish; not lustrous .. .. .. **Pear and Apple**

20. Rays fairly distinct with a lens. Ripple marks sometimes present 21

20. Rays indistinct even with a lens. Ripple marks absent **Willow** or **Poplar**

21. Rays irregularly spaced, mostly separated by the width of two or more pores .. .. **Lime**

21. Rays closely spaced, mostly separated by the width of one pore only **Horse chestnut**

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